# Materials & Methods

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December 1948

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# Materials & Methods

VOLUME 28, NUMBER 6 • DECEMBER, 1948®

## FEATURE ARTICLES



## MATERIALS & METHODS MANUAL NO. 44



## ENGINEERING FILE FACTS



## SEMI-ANNUAL INDEX



## DEPARTMENTS



**NEXT MONTH:** Price and Supply Outlook for 1949 . . . Manufacturing Techniques Tend to Reduce Machining . . . Secondary Metals Now Accepted as of High Quality . . . Intelligent Use Overcomes Misconceptions About Plastics . . . Is It Cheaper to Buy or Make Parts? . . . Needed—Coordination Between Materials, Design, Production . . . Are H-Steels Being Accepted? . . . REVIEW OF MATERIALS ENGINEERING DEVELOPMENTS OF 1948 (Materials & Methods Manual No. 45)

# The MATERIALS OUTLOOK...

With election returns accepted, calmly or otherwise, steel producers, the old New Deal's favorite "whipping boy," await Congressional spankings during next session. . . . Possibilities: Increased Government regulation, distribution-wise. . . . Government-sponsored expansion of primary capacity. . . . Profit reduction. . . . T-H law overhauling, portending 4th round wage demands.

Other straws in the Congressional wind: Imported-metal tariffs may be pared and previous 4-cent copper duty, now in suspension, may be completely lopped off. . . . War-time bonuses to low-content, high-cost mines may be reinstituted. . . . But this won't necessarily boost overall production. . . . Labor apt to gravitate to bonus mines where man-hour output is lower.

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Meanwhile, steel still struggles against demand. . . . Ingot production now highest in history, war years included . . . but metal just as hard to get as before.

Resumption of output at Mystic since furnace-relining job now crowding average maximum possible. . . . Result: N. E. foundries in better position to increase percentage of pig in melting ratio from here on out. . . . Recent use of abnormal scrap-to-pig ratio has boomeranged in some instances. . . . Caused increased machining failures and higher ultimate costs. . . . But Mystic may revise its prices upwards in January. . . . Increased operating costs blamed.

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Central Foundry Div. of GMC now using 100% annealing of soft gray iron castings. . . . first time on large scale. . . . Result: Tool life four times normal when machining. . . . no hard spots to slow machining operations.

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German steel scrap immigration rising steadily. . . . Classed as No. 1 heavy melting grade. . . . already processed, ready for open hearth use. . . . Claimed to be much better quality than that available from domestic sources. . . . Carnegie-Illinois has options on more than 200,000 tons.

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Progress in production of sponge iron by continuous process reported. . . . but some difficulties yet to be overcome. . . . Tests at Bureau of Mines pilot plant at Laramie, Wyo. confirm this. . . . Heat control and distribution still the major bugaboo.

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National economies of South American metal-producing countries geting shot in the arm by intensified mining operations. . . . continued developments may cause S. A. nations to switch from "have-not" to "have" category in world market. . . . Case in point: Current annual U. S. imports of Bolivian tin running about 35,000 tons. . . . and we use close to half a million tons of copper from Chile, Peru, and Bolivia each year.

As an additional hypodermic, U. S. Steel's interest in S. A. iron ore continues. . . . particularly in Brazil and Venezuela. . . . Mining concessions recently acquired on basis of exploratory drilling south of Orinoco River. . . . but no definite plans regarding actual development made as yet.

And speaking of "have-not" nations, U. S. currently hits that category in regard to good chromium ore. . . . But our richest deposits now being developed at fast pace. . . . Annual production of 300,000 tons expected by mid-1950. . . . Cleaned chromite from Twin Sisters Mine in

*(Continued on page 4)*

# The Materials Outlook *(Continued)*

Washington now ranging from 50.0 to 60.4% content. . . . National "high-grade" average runs about 48%. . . . Approximately one-third of total U. S. consumption in '50 expected from these workings.

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Lithium getting increased attention from Bureau of Mines. . . . Reason: Useful alloying element and refining agent. . . . low specific gravity. . . . low melting point. . . . good reaction with water, oxygen, nitrogen, hydrogen, and carbon. . . . Big disadvantage: Expensive and cannot be handled like most metals. . . . Bureau interest centers on producing lithium chloride from ore and producing metal directly from ore. . . . Canadian lithium-containing deposits show promise for future.

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Mercury production in doldrums because of current low prices. . . . But Munitions Board stockpiles strong. . . . During war, 197 domestic mines produced. . . . now only a couple functioning. . . . Mercury dumping by Spanish-Italian cartels blamed for $58-per-flask price. . . . British Government fixed $281 per flask as "fair" price. . . . There's the answer.

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Diversification gains impetus among big metal producers. . . . Latest to spread out is Kennecott Copper, with purchases of titanium-bearing and gold properties in Canada. . . . Movement partly offsets deficit of diminishing domestic copper and lead resources.

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Raising the ante on zinc a half a cent a pound brought quick action around the table. . . . and the no-limit pot grows. . . . Example: U. S. Steel subsidiaries now use formula-pricing technique for automatic gains or sags (?) in prices of zinc-coated products. . . . Results: Carnegie-Illinois ups extras for galvanized sheet products $1.25 a ton. . . . National Tube decreases base discounts on galvanized pipe a half a point, *i.e.* boosts price a dollar a ton.

And as table stakes climb, Climax Molybdenum hoists prices on molybdenum products an average of 18% effective Jan. 1. . . . U. S. Rubber follows suit by upping lead-encased cables 10%. . . . non-metallic sheathed cables 5%. . . . Sharply rising materials, labor, and production costs blamed. . . . And the showdown hasn't come yet.

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Lead and zinc market continues to boom. . . . no slump in sight. . . . Die casters still favor zinc over aluminum, price-wise. . . . Slab zinc production slated for boost in '49. . . . Big lead demand stays high. . . . especially from television tube makers. . . . But lead lags in pigment field. . . . titanium nosing ahead. . . . Greater hiding power. . . . one-coat coverage. . . . still biggest titanium advantage.

Molybdenum another strong pigment-field contender. . . . British currently using molybdenum in conventional lead chromate. . . . Produces orange and near-red pigments with desirable properties of ordinary lead chromes. . . . adds brilliance, staining power, and opacity to deeper shades. . . . Over here we call these pigments moly-orange.

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Newcomer to the alloy steel team is Crucible's HY-Tuff. . . . originally developed for aircraft use. . . . Contains silicon, manganese, nickel and molybdenum for high hardness and toughness. . . . Withstands 27% more stress than conventional steels. . . . Can be flash and arc welded. . . . Has good notch impact resistance. . . . and can be annealed for satisfactory machining.

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Price of standard ferromanganese, F.O.B. producing or stock point, was erroneously reported in Materials Outlook, October issue. . . . Price actually went up from $145 to $160 per gross ton.

AN EDITORIAL

# It's All Done With Mirrors

A good hard look at themselves every once in a while is profitable for people, businesses, institutions and professional fields. The mirror treatment may sometimes be hard to take, but it is bound to be beneficial where applied with intelligence.

Materials engineering as a professional field and function is still in its formative period of rapid growth and, therefore, ripe for the benefits of self-analysis. In the past ten years the number of "full-time" materials engineers has more than doubled and the number of other technical men having a major interest in the engineering materials applied to product manufacture has multiplied several fold. This is the result of the rapid development of new materials, the increasing severity and specialization of new applications, and the consequent growing need for specialists in the service and working characteristics of the dozens of different materials now available.

Indeed this growth has been so rapid that the integration of the field as a whole has been left behind. Materials engineers bear various titles (from "materials engineer" itself through "metallurgist" and on to "standards engineer," depending on the industry and company involved) although basically they are all performing the same function. In some plants they are organized into "materials" departments; in others they are scattered—some in metallurgical engineering, others in general engineering, still others in process engineering departments. The field as a whole and industry in general will surely benefit as the integration present in the leading plants—the use of materials engineering titles and centralized departments—spreads throughout the others.

Many manufacturers, recognizing the need for specific attention to the selection and processing of materials, have made it one of the jobs that some overburdened design or production engineer must do, along with his other duties, instead of setting-up materials engineering as a full-time function. Fortunately this part-time approach—often a desperation measure to assure *some* attention to materials—is being widely replaced with full-time programs. Full-time materials engineering is, if anything, more essential to most plants than full-time design engineering, for the problems related to the procurement and processing of materials go on even after new product design may have stopped.

The demand for trained materials engineers is becoming so great that colleges will be forced to establish full curricula and degrees in materials engineering, as Syracuse University, for example, has recently done. Similarly the time is approaching when materials engineers, under the pressure of their basic community of interest and their eventual numbers, will have to be organized into an association devoted exclusively to all their professional and technical problems.

Dreams? Not at all—it's the classic pattern of development of all important professional fields, and materials engineering is already far along toward its maturity. But it will take more than mirrors to finish the job!

FRED P. PETERS

Materials & Methods
DECEMBER 1948

When die castings are so designed that trimming can be done by machine, costs are reduced.

# How to Save on the Cost of Die Castings by Proper Design and Specification

by JAMES L. ERICKSON

***Given here are some of the factors which have a great bearing on the cost of producing die castings and which can be controlled.***

MANY DIE CASTING BUYERS are paying a premium for alloys, dimensions, pressure tightness, mechanical strength, surface appearance, internal threads, inserts, and/or a dozen other characteristics which they actually do not need. Some of these could have been achieved at lower cost had the purchaser merely revised the part design or choice of alloy.

All die casting buyers take special pains to avoid paying too much by purchasing the die castings they

need on a bid basis, but few die casting buyers actually are aware of how they themselves can effect price savings by not demanding die castings possessing qualities or characteristics which are not essential to the particular part's future service.

Too few die casting buyers are cognizant of the individual and most valuable role, from a price standpoint, which the die caster can play in determining part costs by merely suggesting how the die casting buyer can best achieve the end results he desires through proper die casting part design—for proper die casting part design is merely *low cost* design. Whenever a die caster pronounces the design of a given part to be improper from a die casting standpoint, he is simply calling attention to the fact that it will be *more* expensive to make as a poorly designed part. Proper design facilitates speedy, low cost production as opposed to slow, high cost production for the more inadequately designed parts. The rules for proper die casting design are well known by most die casting buyers; however, only a minority fully appreciate that an infraction of these innocent appearing rules can skyrocket prices. Even fewer fully understand how the various rules are directly related to the individual production costs (within the die caster's plant) that determine to a large extent the price the die caster must necessarily charge for the die castings he produces.

## Die Cost

It is true that the initial cost to the die casting buyer of the necessary dies to produce die castings is high compared to the cost of permanent mold casting dies. It is also true that the cost of die casting dies is often higher than need be were the design and/or the dimensional tolerances of the part in keeping with sound part design and the dimensional limitations of standard die casting procedure. The die casting buyer must remember that die casters always quote the cost of constructing a die casting die which will faithfully produce a die cast part conforming precisely to the part print (and other pertinent data) which the die casting buyer submits for quotation. Altering the particular design of the part which the die casting buyer has originally submitted frequently makes it possible to employ a less expensive die casting die. It is always good policy on the part of the die casting buyer to consult closely with the prospective die caster of the part.

The principal factors influencing the cost of die casting dies are: (1) the overall geometrical size of the part to be die cast; (2) the part weight; (3) the part design; (4) the size, shape, and intricateness of undercuts or cored holes in the part; (5) the mechanical strength properties required; (6) the degree of pressure tightness required; (7) the type of surface finish required; (8) the dimensional tolerances to be held; (9) the need for the parts to possess internal threading; (10) the type of heavy metal inserts required, if any; (11) the need for the part to be free of any flash of certain surfaces; and (12) the alloy required.

## Raw Materials

When a die casting buyer specifies without reservations a given alloy, he often adversely affects the cost of die casting the part he requires by so doing. This is especially true in instances where the alloy called for could be replaced by a less expensive alloy without sacrificing any of the ultimate serviceability of the part. The reason for this is that (a) not all die casting alloys cost the same; (b) not all die casting alloys are equally obtainable; (c) some die casters are equipped to handle properly only two or three of the different die casting alloys at one time without contaminating one with another; (d) not all of the die casting alloys possess equal die castability; (e) certain die casting alloys require special degassing and/or fluxing techniques; (f) not all die casting alloy scrap has the same re-sale value; (g) not all die casting alloys possess equal machinability; (h) not all die casting alloys polish with equal ease; and (i) certain of the die casting alloys are more prone to iron pick-up than others.

When a die casting buyer haphazardly specifies a special die casting alloy and permits no substitutions, he may be automatically forcing the die caster to charge him a premium over and above what it would have cost, had the die caster been able to use another alloy of equal quality or property. Above all, die casting buyers should guard against specifying alloys which call for special casting, foundry, or machining procedure or techniques, unless, of course, they are willing to pay a premium in order to obtain some particular property peculiar to one certain die casting alloy. Special alloys call for special techniques whose costs the die caster necessarily must pass along to the die casting buyer.

## Rate of Die Casting

As it is the practice of many die casters to charge their overhead per day against the total number of die casting hours per day, *i.e.,* on the basis of so many dollars per die casting machine operating hour, the piece price of a given die casting is dependent in part upon the number of individual die castings produced per hour. Thus, if the hourly overhead to be charged against one die casting machine is $5.00 and only 100 die cast parts are produced per hour, the overhead cost per individual die cast part is $0.05. However, if the part is produced at the rate of 1,000 die cast parts per hour (say with the aid of a ten-cavity die casting die), the overhead cost per die cast part is only $0.005. From this example it can be seen that the rate per hour at which a given part can be die cast has great bearing on the production of the overhead to be charged against the individual die cast part; consequently, factors that influence the rate of producing a given part affect the ultimate piece price considerably.

The factors which most determine the rate at which a given part can be die cast are: (1) the alloy employed—some alloys permit much faster die casting die operation than others; (2) the type of die casting machine required to produce the part—certain die

casting machines can actually be operated at high speeds, or casting cycles, than others; (3) the number of parts which can be die cast per *shot* or casting cycle; (4) whether or not inserts are required; (5) the act of placing loose die pieces into the die casting die on the part of the operator in each die casting cycle—the insertion of loose die components as are required in certain instances where it is necessary to die cast a part possessing internal threads or undercuts takes time and slows down the die casting cycle; (6) the number and nature of any sliding cores in the die casting die—sliding cores generally call for a cleaning operation every few cycles of casting; (7) the part's weight—small thin walled die castings of light weight can usually be die cast at much higher speeds than thicker walled castings.

Also, (8) the shape of the part—large overall geometrical size, as opposed to weight—limits the number of parts that the die caster can make from a given die casting die and thus limits, in turn, the number of die cast parts which can be made per hour; (9) the type of surface finish required—the finish called for determines in part how fast a given die can be operated; (10) the mechanical properties required —to obtain certain mechanical properties it is necessary to employ certain types of gating and venting and the presence of these in turn when present in the die, often prevent it from being run at top speed; (11) the dimensional tolerances required; and (12) the degree of pressure tightness called for—extreme pressure tightness, like certain mechanical properties, is only obtainable under highly controlled die casting conditions.

## Trimming the Die Casting

Die cast parts are host to flash when they are removed from their respective die casting dies; this flash must be removed from the die cast part by the die caster. The specific method by which the flash will be trimmed depends upon where the flash occurs on the surface of the part as well as upon the total number of parts which are to be trimmed. If the production run of the die cast parts is short and the flash occurs solely on the outside periphery of the part, it is generally removed with the aid of hand-type rotary files. On the other hand, if the production run of the part is long, a trim die is constructed by the die caster and he removes the flash with this. When the quantity of parts required is very large and the parts are made with the aid of a multiple cavity die casting die, the die caster usually trims the die cast parts with the aid of a gang trim die.

Factors affecting the cost of trimming a given die cast part are: (1) the total number of parts to be trimmed—where the total number of parts ordered is high, the die caster can employ economically a trim die as opposed to cases where the number of die cast parts required is small; (2) the location of the flash on the surface of the die cast part—if the flash can be trimmed with one stroke of one trim die, the cost of trimming the part is, of course, less than if the flash is inaccessible and hand trimming of cored holes and slots is necessitated; (3) the overall size and complexity of the part—on the whole the larger the geometrical size of the part, the more expensive it is to trim the part; and (4) the alloy of which the part is die cast—the trimming of flash by means of a trim die is affected by the die casting alloy employed because certain alloys tend to trim more "clean" than others.

## Machining the Part

Whenever a die casting buyer calls for extremely close (or overly close) dimensional tolerances, tiny holes, internally threaded bosses, and ribs, walls, and bosses with parallel sides free of any draft, he almost always makes it necessary for the die caster to machine the die cast part in order to have it conform to the specifications he has set. Naturally, the buyer is charged for any machining operations which must be performed (such costs are estimated and figured in the die caster's original price proposal to the die casting buyer). The closer the tolerances called for, the more costly are the subsequent machining operations and, therefore, the higher the piece price of the die cast part.

The obvious factors that affect the cost of machining a given die cast part are: (1) the closeness of the dimensional tolerances as specified; (2) the number and the complexity of the machining operations; (3) the kind of tools, jigs, and fixtures needed; and (4) machinability of the alloy used.

## Maintaining Dies

In the course of operating a die casting die it is subject to certain wear and tear that is nearly in proportion to the number of moving parts to which the die casting die is host. In addition, cores are subject to "wash" or "erosion" due to the impingement effect of the incoming molten metal stream which has a tendency to literally "wash" away the outer surfaces of the cores and other portions of the die cavity that are subject to the initial force of the incoming molten metal rays. Such erosion eventually alters the dimensions of the exposed core or die face, and when these dimensions are critical, it becomes necessary to replace the cores with new ones of the proper dimension. Small cores wear away the quickest (even faster as the temperature of the casting alloy increases, *viz.*, zinc-base alloys do not have so damaging an effect as do the aluminum or copper-base alloys). Small cores are also susceptible to heat checking at an earlier number of shots than are larger ones, and, therefore, small cores require more frequent attention and replacement than do the larger ones. As a rule die maintenance costs rise as the number of small cores within a die cavity increases.

The amount of maintenance a die casting die requires is in proportion to the number of moving parts in the die's make-up. The reason for this is twofold: (1) All moving parts of the die casting die call for continual lubrication; otherwise, if they were left unattended they would freeze-up and gall seriously. This is particularly true of moving or sliding cores. Consequently, considerable attention from a lubricating standpoint is required on the part of the

*If many hand operations, such as deburring, are required on die castings, cost per piece is certain to be high.*

die casting machine operator to make certain that each moving member is continually lubricated. (2) All moving parts are subject to continual stress: When a sliding core is withdrawn from the die casting it suffers a tensile stress as it pulls away from the metal which has solidified around its projecting core-end, or core-tip. In cases where the draft on such core-tips is small, the tensile stress may become quite high, and over a period of time this continual, or repeated tensile stressing results in the fracture of the core-tip, whose subsequent replacement comes under the heading of die maintenance.

The absence of adequate draft on the die cavity sections places undue, repeated stress on these sections and can ultimately lead to their actual fracture—to say nothing of the fact that inadequate draft allowances tend to cause the die casting alloy, which is somewhat soft just prior and during the time of its ejection, to cling to the die cavity surface, causing drag marks on the die cavity face which the die casting machine operator has to clean off. If the operator fails to keep the die casting die cavity free of drag marks, the die soon becomes difficult to operate as the die castings tend to stick in, or onto it, and prevent easy and smooth ejection. Also, drag marks on the surface of the die cast parts are frequently cause for their rejection.

Sharp corners on a die cast part, except at the parting line, call for sharp corners within the die casting die cavity. Such sharp corners in the die cavity act as focal points for the fatigue of the die steel and bring about the premature need for die repair and maintenance. They should, therefore, be avoided.

Ejector pins are also a major source of "downtime" (as the die caster calls it when he has to stop for die repair or maintenance), for they are subject to continual wear, high compressive stresses, and heat checking.

All-in-all die casting dies of simple design are the easiest to maintain.

## Reworking Scrap

Provision is always made in the die caster's plant for the re-working of the scrap which he generates as a result of normal die casting operations. Such scrap is routed back to the metal refining department, where it is fluxed and degassed, and, if necessary, re-alloyed to the proper chemical composition.

If the scrap produced from job *A* is in any way different in composition (or if it contains heavy metal inserts) from the scrap produced by jobs *B,C,D,* etc., the die caster has to handle the scrap from job *A* separately. This sort of special handling naturally makes it more costly for the die caster to process the scrap produced from job *A* than from the other jobs; consequently, the die caster must take this fact into consideration when he quotes on the cost of die casting a given part that calls for a special alloy. The result is that the die casting buyer is charged a *premium.*

When scraped or rejected die cast parts contain heavy metal inserts, they cannot be remelted in the normal fashion lest the presence of the inserts contaminate the casting alloy. Insert reclamation is usually accomplished by taking advantage of the difference in the melting points of the casting alloy and the inserts: the latter being recovered from the melt just as soon as the casting alloy has melted and before the inserts have a chance to alter the chemical composition of the melt. Recovering the inserts from scrap or rejected castings therefore calls for a special foundry procedure, and here again the die casting buyer must pay in terms of a higher piece price than were no inserts required.

## Die Set-Up

The number of parts a die caster is permitted to run out at any one single setting of the die without interruption has great bearing on the price he charges for producing the parts. The reason for this is logically justifiable from the die caster's point of view: He is, in effect, selling his die casting machine time; consequently, whenever his die casting machines do not operate during their regularly assigned working hours, his overhead, and in many cases his direct labor costs, continue, while he is actually losing the profit he would ordinarily derive were the die casting machine producing die castings. It is no wonder, therefore, that the die caster must take this loss, or possible loss, into consideration when he bids on a given job, for every time he either puts on or takes off a given die casting die he stands to lose money. Generally, he compensates for the actual profit lost from "downtime" by charging the die casting buyer a die set-up charge. Frequently there is no charge for setting-up the die casting die the first time; however, each subsequent time the die caster may present the die casting buyer with a specific die set-up charge. Not all die casters, however, follow this procedure—some prefer to amortize the die set-up charge over the total number of die cast parts produced during any one given production run. In any event, however, the die casting buyer is charged with the time taken to get a die casting die into operation.

In conclusion, the various factors that tend to increase the cost of die casting a given part are: (1) Large geometrical size and high weight; (2) intricate and complex shape; (3) the presence of undercuts; (4) the need for any cored holes whose axis is not normal to the plane of die parting; (5) the need for an uncommon die casting alloy; (6) the need for special properties: high electrical conductivity, for example; (7) very close dimensional tolerances; (8) the need for pressure tightness; (9) the need for heavy metal inserts; (10) the need for special mechanical properties, such as very high yield strength; and (11) improper part design as a whole.

A host of seemingly unrelated factors have a bearing on the cost of die castings. Frequently one factor alone can act to increase price to an unexpected extent. It is wise, therefore, when purchasing die cast parts to remember that while die casters are fully prepared to execute some rather elaborate production jobs, they prefer to have their present and future customers appreciate the benefits cost wise that are to be gained from following standard and accepted part design principals and from allowing the die caster as great a latitude as possible when it comes to matters of alloy choice and dimensional tolerances. The most important thing for the die casting buyer to keep ever in mind is that it is the end results of *part service* that he should be concerned with—let the die caster assist in achieving these end results through proper design of parts and correct alloy selection, for in so doing the resulting price to be paid for the die casting die and the individual die castings will be reasonable and without added premium.

# Judges Chosen for the 1948 Materials & Methods Achievement Award

Harvey A. Anderson

With 1948 drawing to its close, and the time for selecting the recipient of the 1948 MATERIALS & METHODS Achievement Award approaching, we are happy to announce the names of the members of the Committee of Award who will do the judging and choose the winner.

Readers will recall from the first announcement of the 1948 Award (M&M, May 1948, pp. 66 and 67) that the Award has been changed from a contest or competition, in which candidates must submit "entries" for consideration, to a simple annual award for the outstanding materials engineering achievement of the year, whether or not it is sought by its recipient. Our Committee of Award, early in 1949, will decide what individual or organization during the previous 18-month period has made the greatest contribution to the advancement of materials engineering. (According to our own broad definition, "materials engineering" is the application of engineering materials to product manufacture.)

This year the Committee of Award will carry a heavier responsibility than in the past, for now they must choose the most important among *all* very recent contributions to materials engineering instead of just among those candidates who sent in entries. The seven nationally-known and distinguished materials engineers who have agreed to serve as judges are excellently qualified through their years of experience in materials engineering to carry out this mission. They are:

*Harvey A. Anderson, Raw Materials Engineer,*
*Hawthorne Works, Western Electric Co., Chicago*

*Oscar J. Horger, Chief Engineer, Railway Division,*
*Timken Roller Bearing Co., Canton, Ohio*

*J. J. Kanter, Supervising Engineer,*
*Research & Development Laboratories, Crane Co., Chicago*

*Jerome Strauss, Vice President,*
*Vanadium Corp. of America, New York*

*Charles L. Tutt, Jr., Assistant to the President,*
*General Motors Institute, Flint, Mich.*

*N. E. Woldman, Consulting Engineer,*
*Montclair, N. J.*

*Donald S. Clark, Assoc. Professor of Mechanical Engineering,*
*California Institute of Technology, Pasadena, Calif.*

The materials engineering developments and achievements to be considered as candidates for this Award may be nominated by those responsible for them, by other engineers, or by the Committee of Award itself. Generally speaking, the following types of achievements are most likely to receive the closest consideration:

*Broad materials engineering systems or programs employed by certain manufacturers;*

*Outstanding applications of engineering materials to improvement of product quality or production cost;*

*Development or application of processing methods exceptionally applicable to certain materials which greatly enhance their usefulness in industry;*

*Development of new materials which represent a major contribution to the field;*

*Special research on materials or processing methods for them which provide a long step forward in our knowledge or application of engineering materials;*

*The solution by an individual or an organization of a major problem in the materials engineering field, which represents an outstanding contribution to better product manufacturing;*

*Any other achievement of an exceptional and broadly applicable nature which falls squarely within the field of materials engineering.*

Although the Committee of Award now carries the full responsibility for finding as well as for honoring the most meritorious recent materials engineering achievement, readers should call our attention to any development that seems distinctly worthy of consideration for this high honor. Such suggestions will be forwarded to the Committee of Award, who will make the final decision, since neither the editors nor publishers of the magazine have any vote in the selection.

Please address all correspondence and inquiries on the 1948 MATERIALS & METHODS Achievement Award to Fred P. Peters, MATERIALS & METHODS, 330 West 42nd St., New York 18, N. Y.

J. J. Kanter

Oscar J. Horger

Jerome Strauss

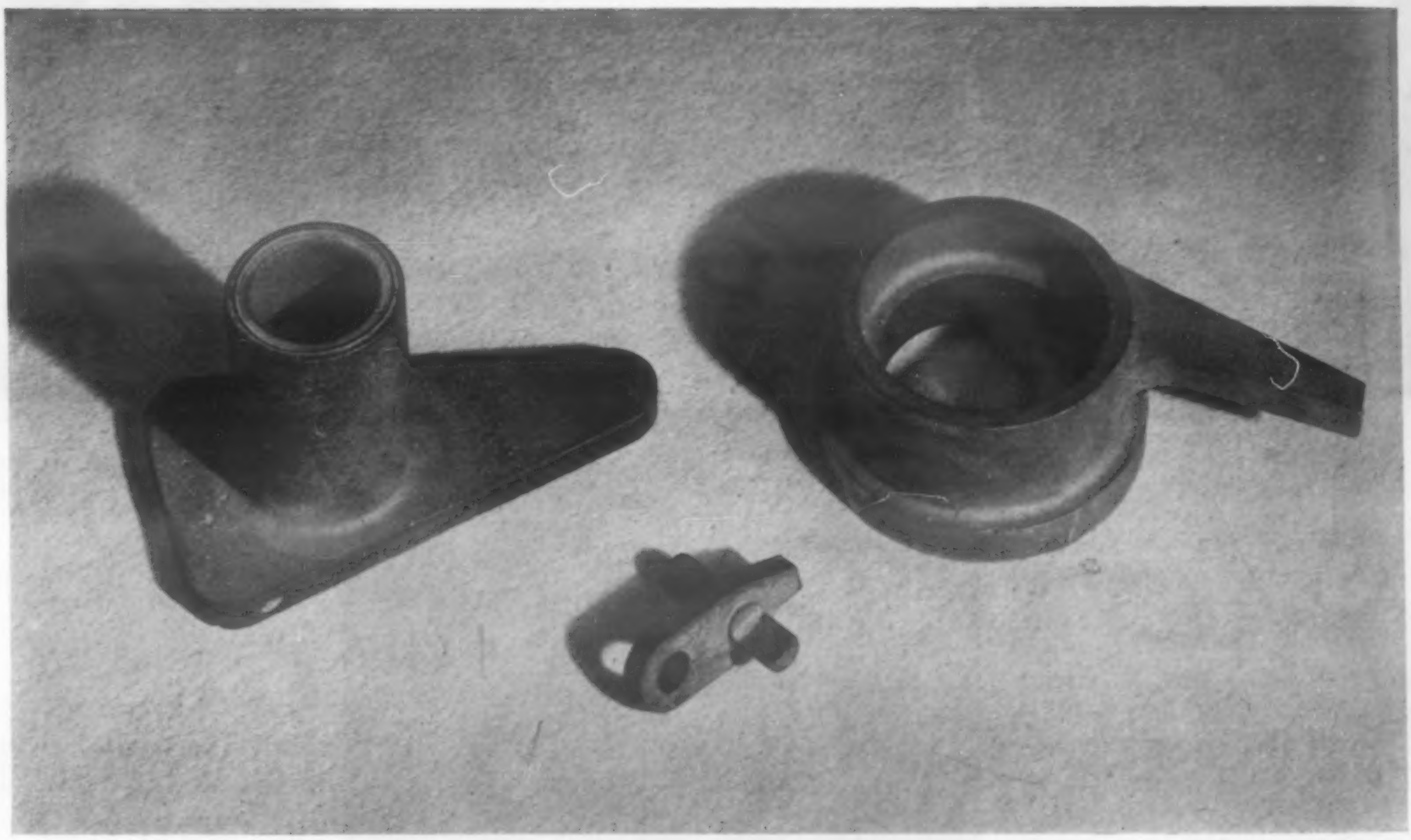
N. E. Woldman

Charles L. Tutt, Jr.

Donald S. Clark

# Heat Treating Used to Vary Properties of Precision Cast Materials

by EDWIN LAIRD CADY

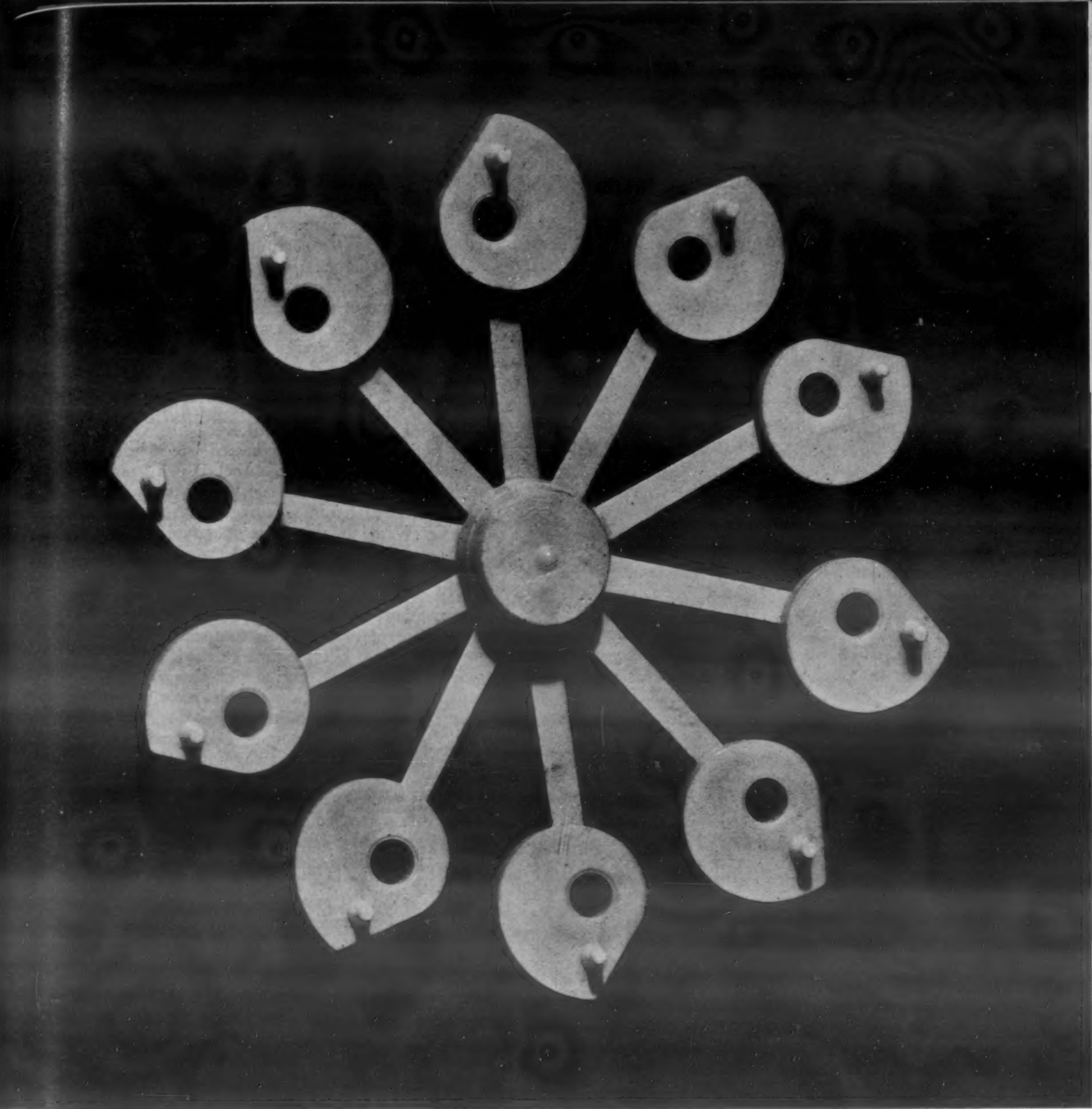


*The 420 stainless steel part (right) and the X4130 part (left) are both for aircraft use. Both are given better properties than as-cast through heat treatment.*

***By using heat treatment on aluminum, beryllium copper, stainless steels and tool steels, a range of properties can be provided with a minimum number of alloys.***

PRECISION INVESTMENT CASTING can make use of thousands of alloys. But the process sometimes is more economical if the casting shop centers its efforts on a few preferred alloys with which its men are thoroughly familiar, uses other alloys only when definitely needed, and varies the properties of its preferred alloys by heat treating the as-cast or as-machined castings.

Centrifi-Cast Co., Inc., 360 West 27th St., New York, N. Y., is an example. This company has on its preferred list such steels as SAE 1075, 4615, 4130, 4340; a limited number of aluminum, beryllium copper and other nonferrous alloys; a few stainless steels



*Stainless steel cams, produced in clusters, are heat treated as a unit to provide a hardness of 37 to 42 Rockwell C.*

and tool steels. It can and does cast other alloys. But by the use of heat treatments the company adapts its preferred types to most purposes.

The heat treating policy is helped by the fact that the customers can be divided into two general types: aircraft and industrial. Aircraft castings are made to strict and complex specifications and the heat treatments usually are closely specified. But an industrial user is more likely to want some one physical property for which it is easy to prescribe a heat treatment, with the other physicals less precisely specified. Thus, heat treatments must be applied in the aircraft field. And the heat treating equipment and personnel are available for adapting alloys to the needs of industrial users.

SAE 4340 is a steel widely used for aircraft parts. It is normalized at 1600 F, being held there for at least 30 min. in order to get its complex carbides into solution, then is air cooled, reheated to 1500 F, oil quenched, tempered for at least 1 hr. at 950 to 1150 F, depending upon the tensile desired. Tensile strengths specified and achieved range from 150,000 to 175,000 psi.

Stainless type 440 has shown an advantage peculiar to precision investment casting, the fact that parts can be knocked out of the flask while still hot and

can be heat treated in clusters. (The cluster is the complete assembly of sprue, runners, gates and castings.)

A cam made of stainless 440 originally was heated to 1800 F, held for 10 min., quenched in oil, tempered at 400 F for 1 hr., thus achieving a Rockwell C hardness of 60.

Abrasion resistance was the purpose of the hardness. The user discovered by test that with a RC of over 35 the part would have abrasion resistance beyond its need. Therefore, the parts are cast in clusters of 10, the flask is allowed to cool to 900 F, the cluster is broken out and allowed to air cool. Stainless 440 has sufficient air hardening properties to achieve a RC of 37 to 42 by this low cost procedure.

SAE 1075 and 4615 are used for two sewing machine parts which are very much alike in their end uses.

One part has teeth which can be of as-cast accuracies. This is made of 1075, cyanided at 1500 F in a salt bath, quenched in oil. The cyaniding makes the teeth wear resistant, the oil quench holds down distortion.

The second part needs teeth having sharper edges than the 0.002 in. which is the ordinary limit of precision cast steel edges, and also needs holes more accurately positioned and spaced than is most economical for casting procedures. This part is cast of SAE 4615, shipped to the user who mills the teeth and drills the holes, then is returned to the casting shop for cyaniding to make the teeth wear resistant.

SAE 4615 often is used in parts originally made of SAE 1020 steel. The machinability of as-cast 4615 is highly satisfactory, it is stronger and more durable, and has fewer warpage and consequent straightening troubles.

Different heat treatments are applied to SAE 4615, depending upon the end use of the part.

One treatment is to cyanide to 0.005 in. to 0.010 in. depth of case, the cyaniding being done in salt bath at 1600 F with time dependent upon case depth desired. The temperature then is reduced to 1475 F and the parts are quenched in oil immediately upon stabilizing at that temperature.

A second treatment is to pack harden at 1600 F for 7 to 8 hr., achieving a case depth of about 1/32 in. If the grain of the case is not required to be fine, the parts are directly quenched from this temperature; otherwise they are cooled in the pots, reheated to 1475 F, and quenched in oil.

Stainless 420 sometimes is heated to 1750 F, quenched, and drawn to achieve a tensile of 125,000 to 140,000 with a hardness of RC 26 to 33. But for many purposes this steel is heated only to the range of 1480 to 1500 F and oil quenched. This procedure yields a modified martensitic grain structure which has the desired hardness range of 26 to 33 Rockwell C. With the lower temperature quench the quench-distortion troubles are fewer, thus, the net cost per satisfactory casting is lower.

Tool steels have been precision investment cast for some purposes and have proven highly satisfactory. The experience of this company with them is growing rapidly but has not reached the point of doing very much testing to find out exactly what properties are being achieved. Successful use in the end product has been the test.

Allegheny Ludlum Seminole Hard grade has been made into screw driver bits having satisfactory shock resistance. The parts were heated in cyanide salt to avoid any change of surface decarburization, quenched in oil from a temperature of 1650. Use of cyanide salt was permissible because the precision investment cast accuracies were such that only a little grinding and no machining had to be done to finish the parts. Hardness of 58 Rockwell C was attained.

As other examples, Allegheny Ludlum Dewar grade has been cast into highly satisfactory blanking

*Type 304 stainless in these parts is annealed at 1800 F and then quenched to achieve a machinability equal to that of wrought stainless.*

and forming dies for thin sheet metal stampings, DBL grade into wood cutting tools. Experience with cast metal cutting tool steel tools has been successful to date, but has not continued long enough to warrant reporting. These two grades are quenched from a temperature range of 1450 to 1475 F to achieve a minimum hardness of 60 Rockwell C.

Stainless type 304 is annealed for 1 hr. at 1800 F and then quenched. By this means the cast structure is so modified that a machinability equal to that of wrought stainless of the same grade is achieved.

SAE X4130 and 8630 are a comparison between aircraft and industrial uses. The X4130 must be used for some aircraft parts to meet the specifications, but for similar industrial applications the 8630 generally would be preferred for its general casting and other handling qualities.

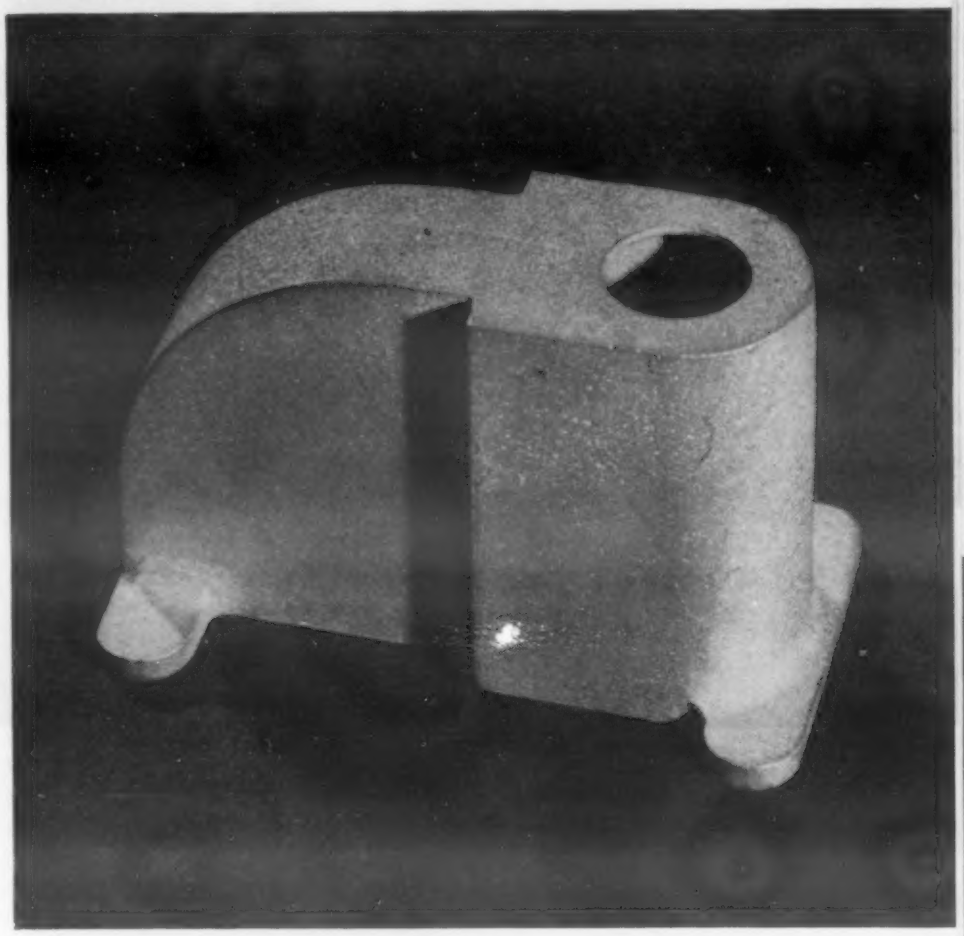
The X4130 is normalized in a salt bath at 1650 F, air cooled, reheated to 1550 F, quenched in oil, and tempered at 1150 F. The original as-cast tensile is about 90,000 psi. By heat treatment a tensile of 110,000 to 125,000 psi. is reached. In one example the specification called for 100,000 psi. tensile with 0.07% elongation; the as-heat-treated castings gave 112,800 psi. tensile with 0.08% elongation and 89,400 psi. yield point.

B195 aluminum in the as-cast condition has a tensile of about 14,500 psi. and a hardness which is below zero on the Rockwell B scale, the hardness being F46 to F52 with a 60-kg. load. As heat treated to T-6 condition, the tensile becomes 38,700 psi. (35,000 being required) and the hardness goes up to 71 to 72 Rockwell B. The material is heated to 950 F in a convection air furnace and held for 8 hr., quenched in boiling water, reheated to 320 F and held for 5 hr., then air cooled.

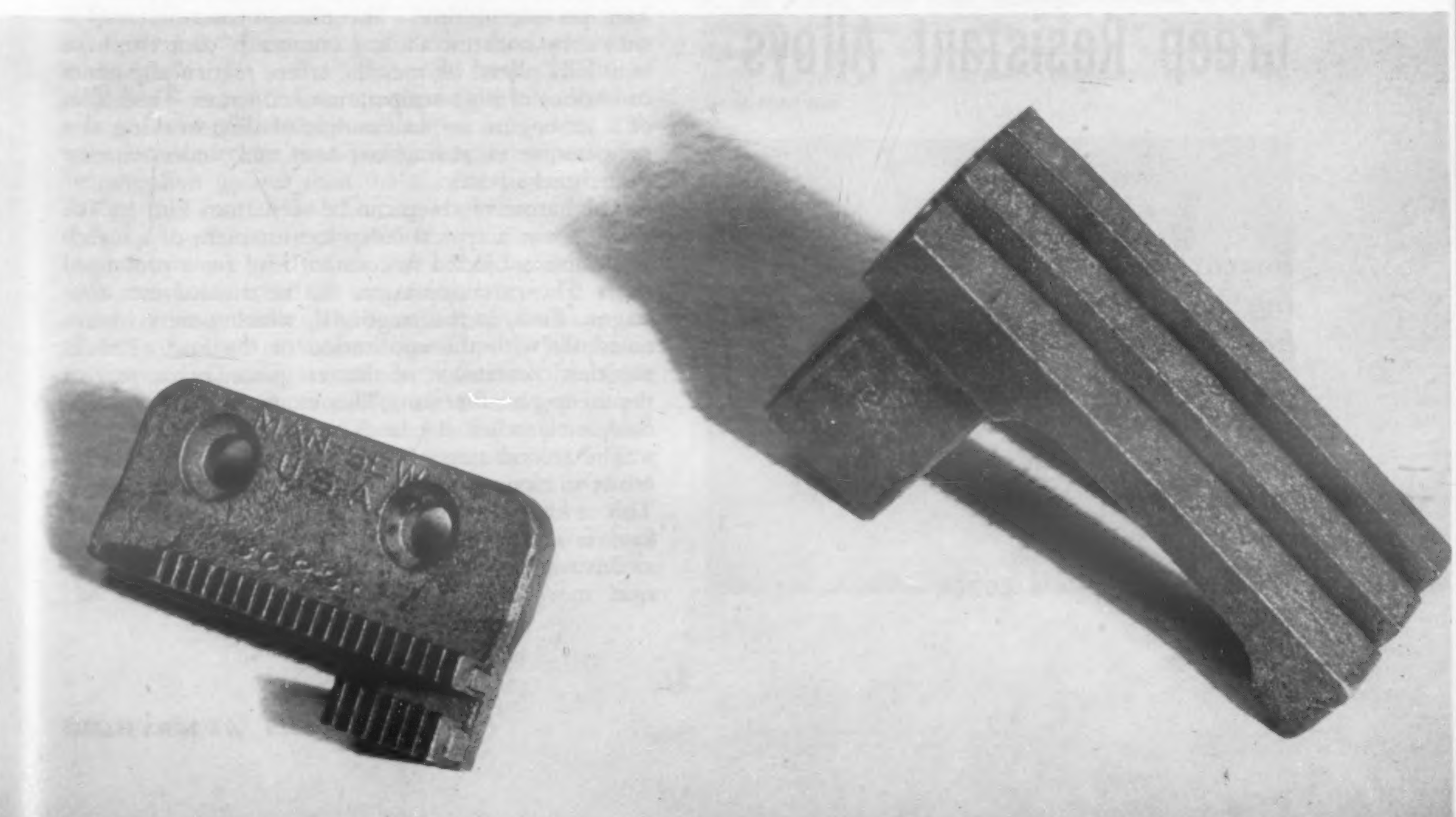
In the as-cast condition, 2.75% beryllium copper is soft enough so that if applied with heavy pressure against a hard object it may mushroom. Parts cast of this alloy are annealed at 1450 F, quenched in warm water, heated to 625 F, held at that temperature for 180 min., and finally air cooled.

By this treatment the parts achieve a hardness of 35 Rockwell C, which prevents the mushrooming but has complete avoidance of undersirable brittleness. Salt baths are used for the heating.

*Tensile strength of this B195 aluminum part was increased from 14,450 psi. to 38,700 psi. by heat treating to the T-6 condition.*



*These steel parts, one with teeth cast in and the other which requires milled teeth, are both cyanide hardened.*



Battery of sensitive creep-testing machines showing control panel. (Photo: Courtesy Thos. Firth & John Brown, Ltd., Sheffield.)

# Methods of Testing Creep Resistant Alloys

***Recent gains in treating and testing high creep resistant alloys have speeded their use in applications where high temperatures and stresses create difficult materials-specification problems.***

**by WILFRED FRANCIS COXON**

CREEP IS THE SLOW, progressive, plastic deformation of material. It occurs when stresses, in themselves too low to cause any permanent deformation under short application, are applied for long periods of time. The phenomenon of creep is shown by both metals and nonmetals. But emphasis is usually placed on metallic creep, particularly under conditions of high temperature and stress. The blades of a jet engine are an example of this, working at a temperature exceeding red heat and under extreme centrifugal stresses.

The nature of creep can be seen from Fig. 1. The graph shows a typical creep measurement of a metallic sample subjected to constant load for a prolonged time. The extension curve can be divided into four stages. First, is the stage *AB,* which occurs instantaneously with the application of the load. This is the elastic extension of the test piece; not a part of the creep phenomenon. This elongation is recovered completely when the load is removed.

The second stage, indicated by *BC,* shows the increase in elongation at a progressively decreasing rate. This is known as the primary creep stage. When the load is removed, most of the elongation occurring at this stage is recovered at a progressively decreasing rate.

The third stage, *CD*, is the secondary or steady-state creep stage. During this period the elongation proceeds at a uniform rate.

During the final stage, *DE*, the rate of creep increases continuously until at some point *E*, the test piece, fractures. The rate and duration of these three stages of plastic extension vary widely. They depend upon the metal or alloy, the load, and the temperature at which the tests are carried out. In deciding the quality of a creep resistant alloy, most importance is attached to the secondary, or steady-state stage and the duration from the start of the test to the beginning of the third creep stage.

The curves in Fig. 2 show the effect of increasing the stress at constant temperature or increasing the temperature at constant stress. The difference is in the duration of the steady-state stage. In the case of *E* at high stresses or temperatures, the stage is represented only as a point between the decreasing rate of creep in the primary creep stage and the increasing rate leading to fracture. With lower stresses or temperatures, the steady creep state is well defined. In curve *A*, however, there appears to be no measurable elongation after the primary creep stage. A conclusion can be drawn that the specimen having this curve can withstand indefinitely the stress to which it is subjected. This has caused experimenters to assign to a given material at a given temperature a limiting creep stress below which the specimen will not fracture. But this is not always true. Much depends on the time period of the test, and the initiation of the accelerating rate of creep ultimately leading to fracture is not accurately predictable for given conditions of stress and temperature from data based on tests carried out under higher stresses and temperature.

Thus, tests for suitability of creep resistant alloys must bear some relation to the service conditions. Where long service life is required, long periods of creep testing must be maintained. Accelerated tests can be applied only if the relation between the stress and the creep properties of the alloy have been established.

Determination of creep in a highly creep resistant metal alloy is an extremely difficult procedure. One method is known as the "time yield" test. This time yield stress is equivalent approximately to a rate of creep of one millionth of an in. per in. per hr. The test piece under the time yield stress should not give an extension greater than 0.5% of the gage length during the first 24 hr. During the next 40 hr., it should show no further extension within a sensitivity of measurement of $10^{-4}$ in. on a 2-in. gage length.

In another method of measuring creep, the stress necessary to produce definite amounts of strain and ultimate rupture in various times up to 300 hr. is determined. Testing machines, sufficiently sensitive to record changes in the order of $10^{-7}$ in. per in. per hr. over long periods, are needed for this method. In addition to which, temperatures up to 900 C must be maintained constant throughout the tests to within $\pm 1$ C.

A practical application of creep determination can be traced in the development of the jet engine. Since the rotary blades are subject to creep from high centrifugal stresses, and as the efficiency of the engine depends largely on the clearance between the blade-tips and the shroud ring, the clearance must be kept as low as possible consistent with the creep to be expected.

The material used for the rotary blades and disks in some early engines was a high chromium-content steel that had been utilized primarily for steam turbines. A typical analysis of this steel follows:

| | |
|---|---|
| C | 0.22% |
| Si | 1.0% |
| Mn | 0.6% |
| Cr | 20.0% |
| Ni | 8.5% |
| Ti | 1.2% |

The normal heat treatment consists of air cooling from 1050 C, followed by re-heatings for 1 hr. at 800 C and subsequent air coolings.

The "time yield" values for this steel were as follows:

| *Temp. deg. C* | *t/in.²* |
|---|---|
| 400 | 22.0 |
| 450 | 19.0 |
| 500 | 14.5 |
| 550 | 9.5 |
| 600 | 7.0 |
| 700 | 1.25 |
| 800 | 750 psi. |

Another steel in previous use was also tested. Its "time yield" figures were as follows:

| *Temp. deg. C* | *t/in.²* |
|---|---|
| 400 | 12.25 |
| 500 | 11.0 |
| 600 | 5.0 |
| 700 | 2.0 |
| 800 | 1000 psi. |

*Fig. 1—Typical creep measurement for a metallic sample subjected to a constant load for a prolonged period of time. Stage AB occurs instantaneously with application of load. In BC, the primary creep stage, elongation increases at a progressively decreasing rate. Stage CD is the secondary, or steady-state, where elongation proceeds at a uniform rate. In DE, the rate of creep increases continuously until the test piece fractures.*

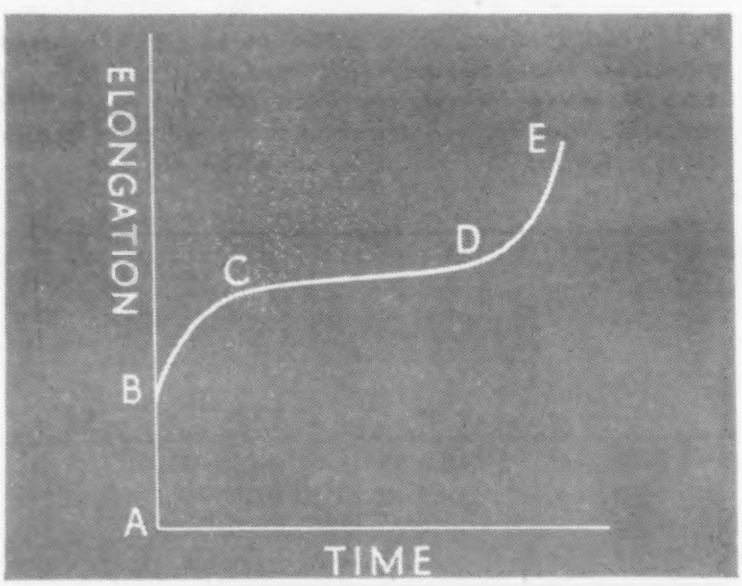
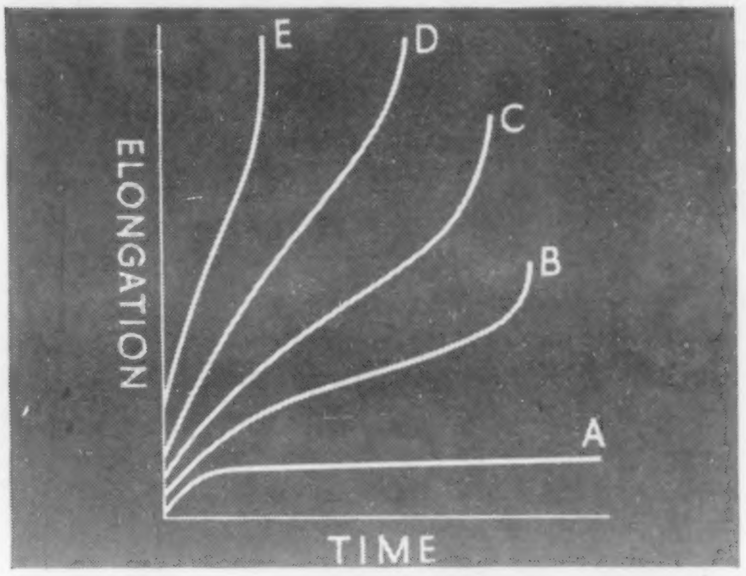


Fig. 2—*Curves showing the effect of increasing the stress at constant temperature or increasing the temperature at constant stress. In E, the duration of the steady-state is represented as a point between the decreasing rate of creep in the primary creep stage and the increasing rate leading to fracture. In curves D, C and B, the steady-creep state is well-defined. In curve A, there appears to be no measurable elongation after the primary creep stage.*




*Left—Creep test extensometer for the "time yield" stress. This is equivalent approximately to a rate of creep of one-millionth of an in. per in. per hr. The test piece should not give an extension greater than 0.5% of the gage length during the first 24 hr. During the next 48 hr., it should show no further extension within a sensitivity of measurement of $10^{-4}$ in. on a 2-in. gage length. (Photo: Courtesy Thos. Firth & John Brown, Ltd., Sheffield.)*

*Right—Test specimen being placed in position. The small mirrors below the operator's left hand show by change in mirror-angle how the specimen alters in length beneath the heat and strain. The cylinder above is the resistance-furnace, which is lowered over the test-piece before the test is run.*

A comparison of the figures for these two steels is interesting. As can be seen, the former steel has better creep properties at temperatures up to 600 C. Above this temperature, the latter material has the advantage.

This comparison brings out a fundamental characteristic of creep testing. Because a particular material has a better performance at some specific temperature, it cannot be assumed that it will be better at another temperature range.

There is a further contributory factor in creep properties: the density of the material. The higher the density, the greater will be the stress. When high percentages of alloying metals such as nickel (density 8.9 gm./cu.cm.), cobalt (8.7), molybdenum (9.0), and tungsten (19.0) are used, they all have a density greater than iron (7.9). This is clearly shown in the case of the high nickel-content steel that was next developed and tested. The analysis of this material follows:

| | |
|---|---|
| C | 0.07% |
| Si | 0.70% |
| Mn | 0.80% |
| Cr | 14.0% |
| Ni | 18.0% |
| Mo | 3.75% |
| Cu | 3.6% |
| Ti | 0.65% |

The heat treatment of this material consists of air cooling from 1050 C, soaking for 3 hr. at 800 C and air cooling; soaking for 48 hr. at 600 C and air cooling.

The "time yield" figures for this steel were as follows:

| *Temp. deg. C* | *t/in.²* |
|---|---|
| 400 | 19 |
| 500 | 18 |
| 600 | 15 |
| 700 | 6.5 |
| 800 | 1.75 |

From these figures it can be seen that this material gives an improvement in creep extension of nearly 100 C over the first steel tested.

Results of further tests on this high nickel-content steel are given in the accompanying table.

Thus, the stress required to produce 0.1% creep strain in 300 hr. is approximately equal the time yield stress at 600 C. But at higher temperatures, the "time yield" method gives a more conservative result.

| Temp. Deg. C | Stress for Given Percentage Creep in 300 Hr. (Tons per Sq. In.) | | | | | | Stress to Fracture (Tons per Sq. In.) |
|---|---|---|---|---|---|---|---|
| | 0.1% | 0.2% | 0.3% | 0.4% | 0.5% | 300 Hr. | 1000 Hr. (Extrapolated) |
| 600 | 15.6 | 16.5 | 17.4 | 17.8 | 18.1 | 19.5 | 17.7 |
| 650 | 10.7 | 11.7 | 12.2 | 12.5 | 12.7 | 14.1 | 12.6 |
| 700 | 7.2 | 8.0 | 8.5 | 8.8 | 9.0 | 10.4 | 8.9 |
| 800 | 2.7 | 3.0 | 3.1 | 3.3 | 3.4 | 4.5 | 2.9 |

***Materials to withstand high temperatures are as important in processing other materials as in meeting end service requirements of such products as jet engines.***

# Pure Oxide Refractories Withstand High Temperatures

by O. J. WHITTEMORE, JR., Norton Co., Worcester, Mass.

THERE HAS BEEN A TREND in many industries in recent years toward the use of higher temperatures. In the conversion of heat into motion or electrical energy, higher temperatures have meant higher production from a power plant without corresponding increase in size, and have shown the way to higher efficiency as well. The chemical industry has found that higher temperatures and higher pressures have made possible some reactions heretofore considered impracticable, and have speeded most others.

All of this use of higher temperatures has presented a series of challenges to the suppliers of materials. While such spectacular machines as the gas turbine and the jet engine, with metal parts running at red heat, have caught the public eye, such unspectacular parts as crucibles and tubes, refractory linings, and furnace muffles have been just as necessary, and just as difficult to produce to required thermal properties.

This demand for refractories to withstand increasingly higher temperatures has prompted the development of a group of special materials called the pure oxide refractories. The distinguishing characteristic of the group is that each is composed of a single refractory oxide. They are intended for service at temperatures above 1650 C (3000 F). Because they are each composed of a single oxide, they are: (1) free from the fluxing effect of the lower melting ingredients in a mixture, and (2) monocrystalline and self-bonded, as opposed to the glass-bonded refractories of the fireclay type. The oxides, in order of increasing cost, are the following: alumina, magnesia, zirconia, beryllia and thoria.

Each of these refractory oxides has special properties that will greatly influence its use. Some of these are here outlined:

*Alumina:*

- Fusion point—2000 to 2045 C (3632 to 3713 F)
- Very stable in both oxidizing and neutral atmospheres
- Practical upper working limit, about 1900 C (3452 F)

*Magnesia:*

- Fusion point—2800 C (5072 F)
- Reduces readily at high temperatures
- Fair to poor resistance to thermal shock

*Zirconia:*

- Fusion point when pure—2715 C (4919 F)
- Stable in oxidizing atmospheres; fairly stable in reducing atmospheres
- Thermal conductivity rather low
- Difficult to use in pure state because of change in crystalline structure at about 1100 C (2012 F), with change of volume
- Stabilized zirconia, containing small percentages of lime or magnesia, stabilized in cubic form, but softens at slightly lower temperatures

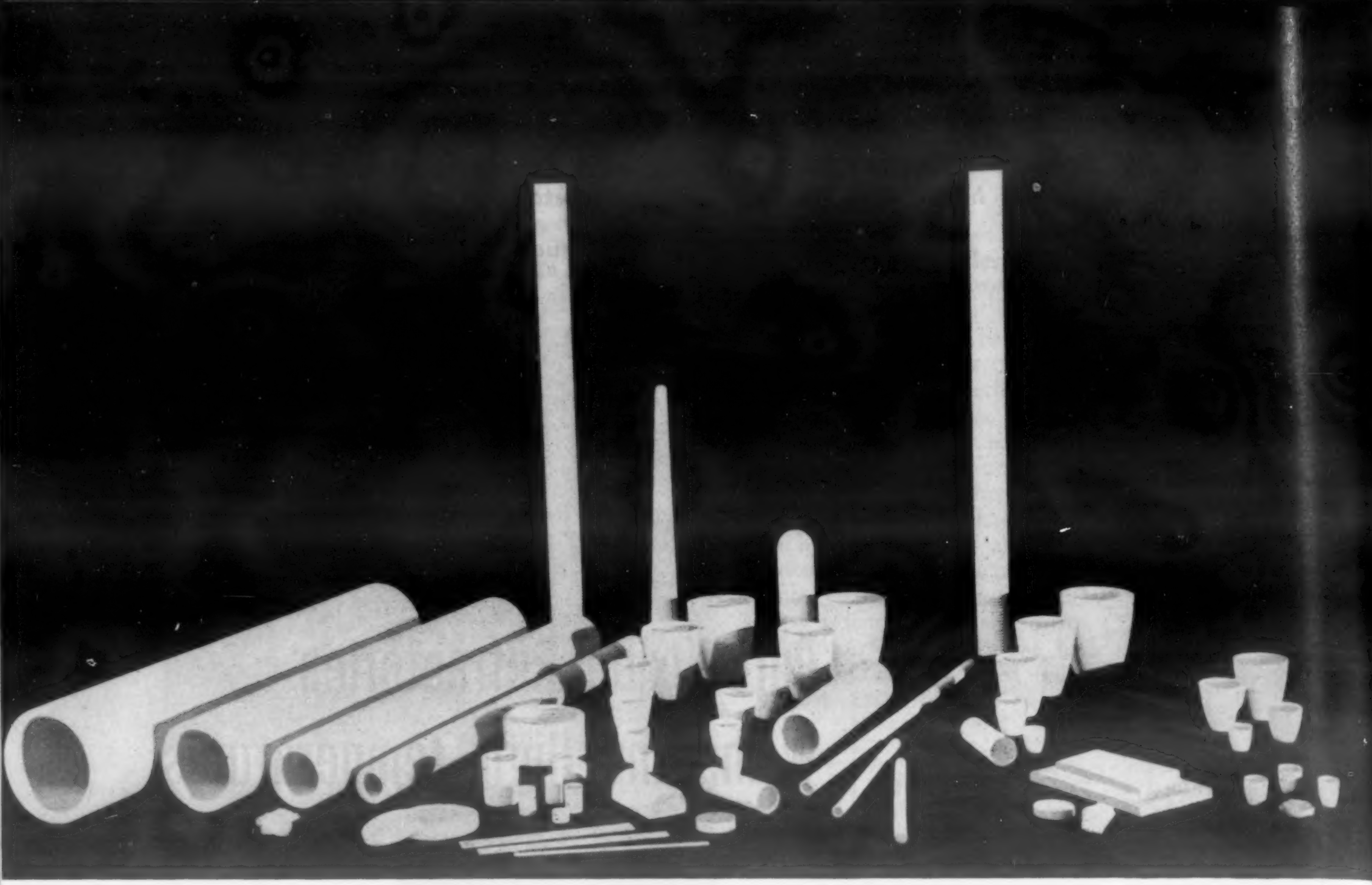


Fig. 1—Shapes in which pure oxides have been used for light refractory applications.

*Beryllia:*

Fusion point—2520 C (4568 F)

Resistant to reduction

Excellent thermal conductivity, comparable to that of metals

Moderately high thermal expansivity, but good thermal shock resistance because of high thermal conductivity

Volatilizes above 1650 C (3002 F) in presence of water vapor

Toxic to respiratory system

*Thoria:*

Fusion point—3050 C (5522 F), the highest of any of the oxides

Heavy; density 9.6 gm. per cc.

Thermal shock resistance poor

Radioactive, therefore toxic

While all of the above-listed oxides have been used for light refractory purposes, such as crucibles and tubes as illustrated in Fig. 1, the high cost of beryllia and thoria limit their industrial use. For heavy refractory uses employing the material as brick, heavy shaped pieces, etc., only the first three need be considered.

A series of tests run upon these three materials in such formulations for fabricated ware as would correspond to commercial practice is intended to show the properties applicable to industrial furnace linings. All were made upon test pieces composed predominantly of fused grain, fired to pyrometric cone No. 35 (about 1750 C, or 3160 F), except the magnesia mixture RM-1109B, which was fired to cone No. 16 (about 1450 C, or 2640 F). The test pieces:

*Alumina Products*

RA-1190-35. A dense, pure Alundum fabricated product of 14-mesh size and finer. It is 99+% $Al_2O_3$.

LA-63A-35. A pure Alundum fabricated product of relatively low density, insulating material, with a grain size of 8 mesh and finer. Also 99+% alumina.

LA-63C-35. Similar in composition to the immediately preceding material, but of higher bulk density.

LA-63D-35. Also similar in composition, but of still higher bulk density.

*Magnesia Products*

RM-1109B. Essentially a fused periclase fabricated product, in size 30 mesh and finer. Chemically, it is 96 to 97% MgO.

LM-171-35. A fused periclase fabricated product, 6 mesh and finer in size. It is 98% magnesia.

*Stabilized Zirconia Products*

LZO-148A-35. A fused zirconia fabricated product stabilized with lime. It is 14 mesh and finer in size. Chemical composition is 98 to 99% $ZrO_2$ with CaO.

LZO-187-35. An insulating stabilized zirconia product, 8 mesh and finer in size. Chemically 98% $ZrO_2$ with CaO.

The determination of porosity and density of the refractories was made according to A.S.T.M. methods. In the results given, the true or total porosity is calculated from the true specific gravity of the sam-

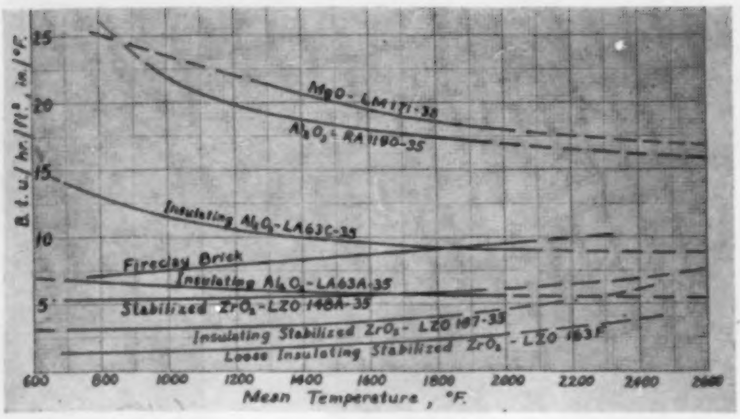



*Fig. 2—Thermal conductivity of pure oxide heavy refractories.*

### Porosity and Density of Pure Oxide Refractories

| Sample | True Porosity, % | Apparent Porosity, % | Bulk Density, Lb. per Cu. Ft. |
|---|---|---|---|
| **Alumina** | | | |
| RA-1190-35 | 23 | 21 | 195 |
| LA-63A-35 | 64 | 57 | 90 |
| LA-63C-35 | 53 | 47 | 120 |
| LA-63D-35 | 42 | 36 | 145 |
| **Magnesia** | | | |
| RM-1109B | 24 | 22 | 165 |
| LM-171-35 | 22 | 20 | 175 |
| **Zirconia** | | | |
| LZO-148A-35 | 28 | 26 | 250 |
| LZO-172-35 | 19 | 17 | 285 |
| LZO-187-35 | 50 | 44 | 175 |

ples; apparent or open porosity is determined from the amount of water taken up by the open pores of the sample; the difference represents closed pores.

An important property in determining the maximum service temperature of a refractory is its volume stability. In test, the temperature at which volume changes become important is determined and reported as reheat shrinkage. The test is conducted by reheating samples to various temperatures and holding the temperature of each for 1 hr. The temperature just below that at which shrinkage becomes significant is the maximum service temperature for the refractory. The linear shrinkage is shown in the accompanying table.

Thermal conductivity was determined by Prof. G. B. Wilkes at Massachusetts Institute of Technology

### Reheat Shrinkage of Pure Oxide Refractories

| Sample | Shrinkage at 1900 C | Shrinkage at 2300 C |
|---|---|---|
| RA-1190-35 | 0.0% | — |
| LA-63A-35 | 0.3% | — |
| LA-63C-35 | 0.1% | — |
| LA-63D-35 | 0.2% | — |
| LM-171-35 | — | 0.3% |
| LZO-148A-35 | — | 0.6% (expansion) * |
| LZO-172-35 | — | 0.8% (expansion) |
| LZO-187-35 | — | 4.0% (shrinkage) |

** In a later test a bar of this material that had been reheated to 2300 C (4172 F) was again reheated to 2400 C (4352 F). No change in length resulted from this additional reheating. A 1-in. cube was then cut from the specimen and loaded at 40 psi. While under load the cube was heated at the rate of 10 C per min. until failure occurred. The cube failed at 2090 C (3794 F).*

in apparatus prescribed by the A.S.T.M. standard test. Results are shown in the graph (Fig. 2). It is interesting to note that thermal conductivity of alumina refractories varies with the density, while the stabilized zirconia product designated LZO-148A-35 gave very low thermal conductivities in spite of its high bulk density of 250 lb. per cu. ft. The conductivity of loose insulating zirconia grain is also shown. This material is excellent as "back-up" insulation. A curve showing the average thermal conductivity of fireclay brick is included for comparison.

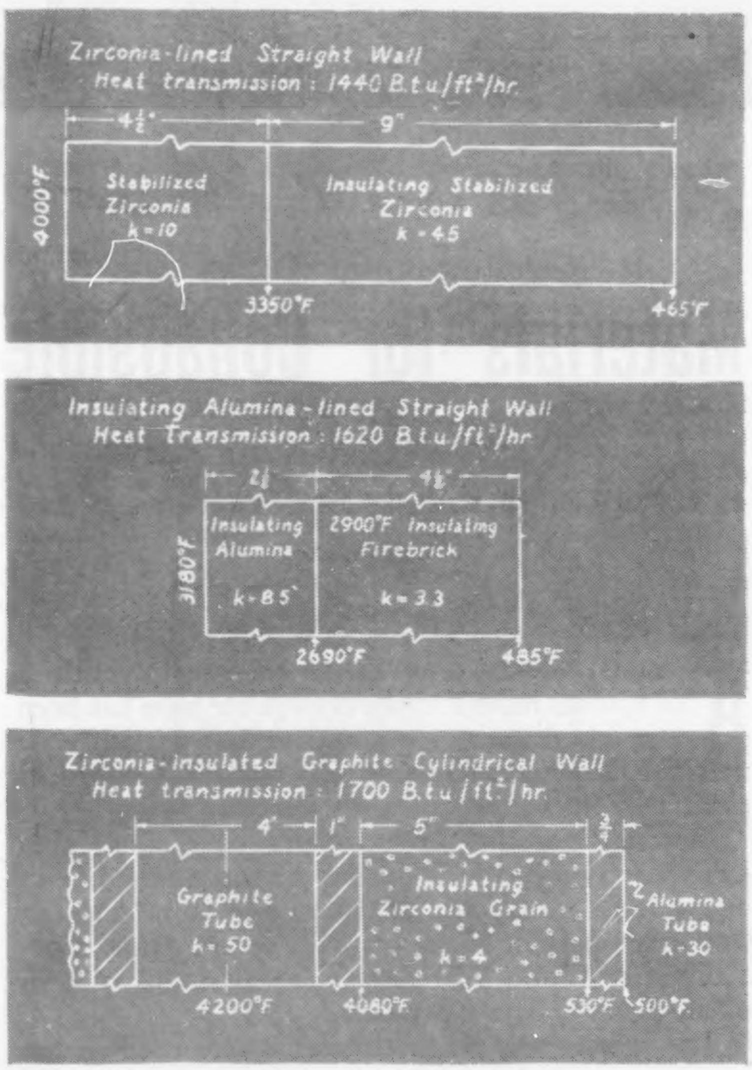
Applying the values of the conductivity coefficients to the construction of two theoretical walls, the use of the types of refractories is shown again in the wall cross-sections (Fig. 3). These compound walls were calculated from the extrapolated curves in Fig. 2, and are based upon a still-air temperature of 80 F outside the furnace.

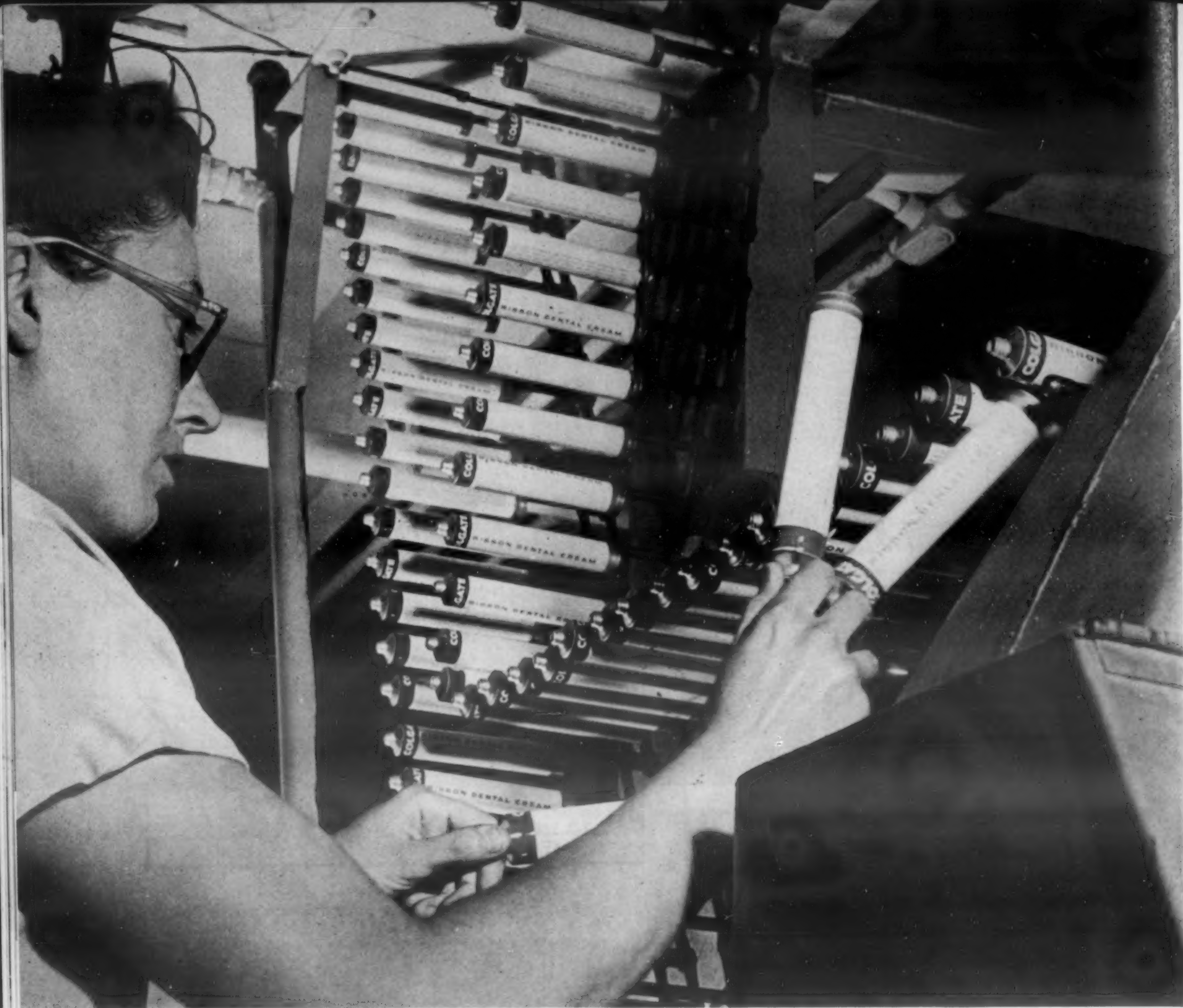
The load-carrying capacity of each sample composition was determined by loading 1-in. cubes of the material with 10 psi. or 40 psi., and heating at the rate of 35 C per min. to 1100 C, then at the rate of 10 C to failure. The results:

### Failure Temperatures

| Sample | 10 Psi. Load | 40 Psi. Load |
|---|---|---|
| RA-1190-35 | 1925 C | 1710 C |
| LM-171-35 | — | 2400 C |
| LZO-148A-35 | 1780 C | 1620 C |
| LZO-172-35 | 2200 C | 1970 C |

*Fig. 3—Theoretical pure oxide furnace walls.*





# Materials for Collapsible Tubes

***Aluminum joins lead and tin as a material suitable for collapsible, disposable tubes.***

**by T. C. DU MOND, Managing Editor, Materials & Methods**

As a disposable container for small quantities of viscous materials, the collapsible tube has been a standard item for more than half a century. It meets requirements so completely that it has remained practically unchanged since its introduction.

Materials for the production of collapsible tubes have been changed little during the same period, with one notable exception. Aluminum has become an important part of the picture in recent years, especially after World War II. Its present status is 30% of all metal collapsible tubes.

The reason why so few materials are used in the manufacture of collapsible tubes becomes apparent with a study of the requirements for a tube material. Some of the important are:

(1) The material must be capable of undergoing extreme cold-working without work hardening appreciably. This requirement alone eliminates most of the metals. Collapsible tubes are formed by impact extrusion, and the process is so efficient and economical that there is little likelihood of its being superseded by anything in the present metal processing techniques.

(2) The material must be soft enough to be easily

flexed, and must retain its softness after repeated flexing. Collapsible tubes are dispensers as well as containers. Again, almost complete freedom from work hardening is a corollary requirement.

(3) Resistance to chemical corrosion must be high for a wide range of corroding agents. Toiletries and medicinals are likely to contain not only water, but chemicals that will actively attack many metals and nonmetals.

(4) No health hazard should be created. For such items as tooth paste and medicinals, even a small pickup of tube material of a poisonous nature must be avoided.

(5) The tube must have a good shelf life. Resistance to atmospheric corrosion is the principal factor involved.

(6) The material must provide an excellent moisture barrier. This is of little importance as between two metals, but it has prevented several nonmetallics from qualifying as tube materials.

(7) The material must be low in cost. Collapsible tubes are disposable containers, and a material so high in price that it would add substantially to the cost of the product being sold would be used only if other requirements made use of rigid containers impractical.

A consideration of the requirements narrows down the list of possible materials to tin and lead, the two metals that have held the preference since the first tubes were made. Whereas most metals are work-hardened to a degree that would make them unacceptable for use as tubes, it is customary to add a little antimony to both tin and lead to increase hardness. Only one other metal, aluminum, has been successful as a tube material, and here the post-war shortage of tin was the spur that intensified the development and use of the aluminum collapsible tube.

Even tin and lead cannot meet all the requirements completely. Tin is too expensive for all purposes for which disposable tubes are used, though it meets most of the other requirements satisfactorily. Lead meets all processing requirements, but has rather poor shelf life, and its use for a container for medicinals and toothpaste was questioned. Therefore, most of the collapsible tubes made today use lead that has been modified in some way so as to circumvent its disadvantages.

Three methods are used to meet the objections to lead. They are:

(1) *Coating with wax.* When toothpaste or certain kinds of medicinals are to be contained in a lead tube, the interior of the tube may be coated with a soft wax to prevent any possibility of lead pickup.

(2) *Alloying with tin.* To improve the shelf life of lead tubes, a little tin may be alloyed with the lead. The amount used is insufficient to do more than maintain the brightness of the exposed metal for a longer period on the shop shelves, but the darkening of the tube was one of the complaints against the collapsible container during the war.

(3) *Coating with tin or tin alloy.* This is the most widely used method. A thin sheet of pure tin, or of an alloy of tin with lead, usually at least 50% tin, is faced over each side of the sheet of lead from which the slugs are blanked for extruding the tubes. As the tube is made in inverted position when impact extruded, the facing layers follow the flow of the lead to within about 1½ to 2 in. of the bottom of the tube—the upper part of the tube as formed. When the tube is filled, also from the bottom, this unprotected portion is hidden when the open end is folded and crimped into a flat seam.

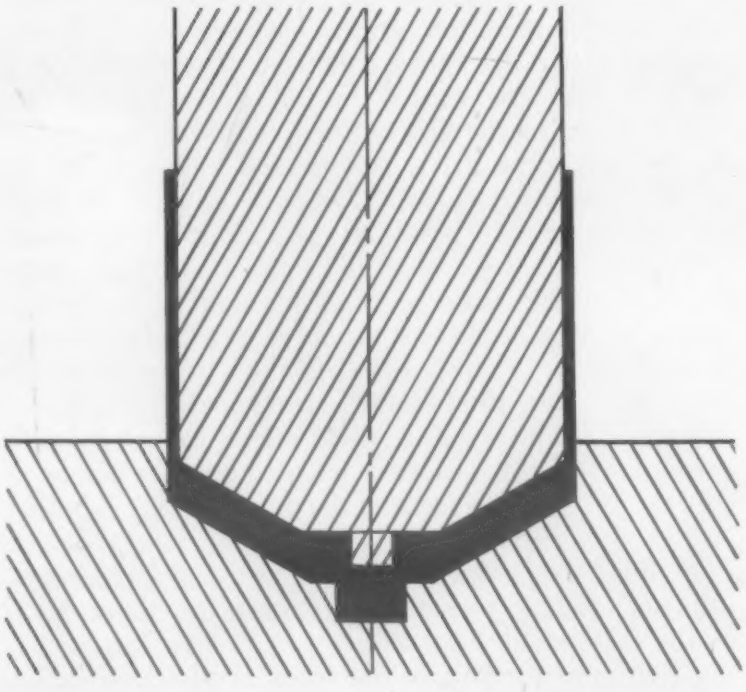
Impact extrusion is a severe cold working operation, usually performed on semi-automatic presses. The tube material, as a slug of carefully controlled size, is placed in the female portion of a die, as shown in drawing. A punch then descends to squeeze the slug so that it fills the die cavity, and the excess metal flows upward, following the straight sides of the punch. The punch then rises, and the tube is stripped from it automatically.

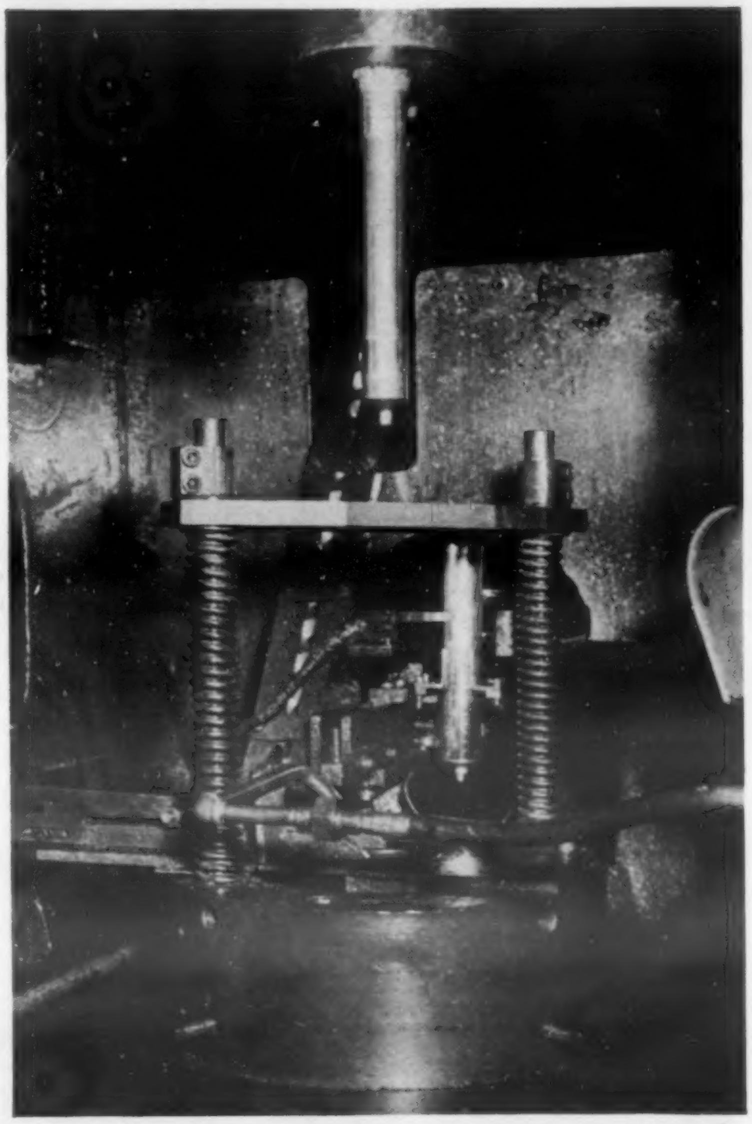
The choice of materials is greatly influenced by Government regulations. During the war, tin, a vital material in war production and also one of which the United States had virtually no supply, was put under strict control. The governmental order M-43, the tin order, permitted the use of pure tin for collapsible tubes for medicinals only. This order is still in effect. Furthermore, tin used in collapsible tubes as either alloy or coating is permitted for toothpaste containers, but only to the extent of 3% of the total material comprising the tube.

For those tubes in which tin is permitted, pure tin used for medicinals is usually alloyed with 2% antimony to harden it slightly. As an alloying or cladding material, tubes may use the allowable 3% of tin as an alloy with the lead to brighten it a little, or it may be used in a "50-50" alloy for protecting the lead body of the tube, as stated.

The all-lead tube is frequently alloyed with 2 to 5% antimony to harden and strengthen it. While a satisfactory shelf life of nine months is required, the war showed that the tubes made were capable of maintaining an acceptable appearance for about twice that length of time.

***Extruded metal flows upward around the punch to form the walls of a collapsible tube.***





*An extruded tube is here shown as it is removed from the impact punch which formed the shape. (Photo: Courtesy Aluminum Co. of America.)*

Although tin now provides only about 7% of the material for collapsible tubes, it once formed 70% of the total. This was the basis for the most successful scrap drive made during the war. Needing tin badly, the government appealed to the Collapsible Tube Manufacturers' Assn. to help in the collection of used tubes. Druggists and stores handling toiletries gave splendid volunteer cooperation, and a total of $620,000 was realized from the tubes collected. After attempting to turn over the money to the Red Cross, it was finally given to the Government. This is reported to be the only scrap drive that made money.

With excellent corrosion resistance, good chemical resistance, low cost, and nontoxicity to offer, aluminum is suitable for containing most medicinals, toothpaste, industrial materials, and many others. Although dead-soft aluminum has a tendency to work-harden, this offers no appreciable difficulty in a collapsible tube since the thinness of the side-wall (approximately 0.005 in.) offers little resistance to pressure exerted to it. By starting with aluminum sheet of 99.7% purity, it is successfully formed into tubes by impact extrusion. Its other qualities have enabled it to hold its post-war gains in the collapsible tube industry, and at present it accounts for about 30% of the tubes made.

Aluminum for collapsible tubes is provided in the special-purity 99.7% metal, to obtain maximum softness. However, strength to protect the contents of the tube is desirable in addition to softness, and aluminum provides this protection. Aluminum tubes are offered in the annealed condition, the annealing operation being performed after extrusion. Excellent printability is one of the advantages that has caused the use of aluminum in collapsible tubes to rise from about 8% pre-war to about 30% at present.

Lead, tin, and aluminum are the materials of the collapsible tube industry. Long and costly efforts have been made to extend this list by adding certain of the extensible plastics, particularly the vinyl polymers and copolymers, but so far these efforts have not brought practical success. The problem that has so far resisted solution is the permeability of thin films of the plastic elastomers to water vapor. Materials packed in tubes of plastic have tended to dry out, even when the end seals were well made. An effort was made to produce the tubes from plastic film laminated with metal foil, but results have not yet been put upon a practical footing.

While plastics have not found successful application in the manufacture of collapsible tubes, a flexible plastic container rather similar in nature has recently come to the market. This is the "squeezable" bottle, made of molded polyethylene, and used as a disposable dispenser-container for both liquids and powders. Liquid toiletries such as deodorants are now being packaged in these flexible bottles, and it is also used for such powdered preparations as insect and rat poisons. The polyethylene is used in sufficiently thick walls so that an adequate moisture barrier is provided, and the material itself has good resistance to acids, alkalies and alcohol.

The disposable container combines protection for the producer of the contained material against illicit reuse, protection for the contents, economy packaging for small quantities of oily or pasty material, and convenience in dispensing such material. Some of the problems in choice of materials for the tube itself come from the wide variety of contents. These may be included under three general classifications:

(1) *Medicinals*: Ointments, lotions, etc., are conveniently handled in collapsible tubes, usually of pure tin, but now increasingly making use of aluminum.

(2) *Toiletries*: Among the largest users of collapsible tubes are the manufacturers of toothpaste, cosmetic creams, shaving soaps, and similar preparations. Tin-coated lead and aluminum are the usual tube materials.

(3) *Miscellaneous*: A heterogeneous assortment of industrial and consumer goods, including items as diverse as lubricants and greases, adhesives, shoe polish, and artists' colors, are contained in collapsible tubes. These tubes are usually furnished in lead or aluminum.

While the tonnage of materials for collapsible tubes is not large enough to make it an important quantity market, the requirements are exacting enough to limit that market sharply to the three metals that have qualified. Materials engineers are searching for new materials that can compete, and there is a likelihood that at least one group of plastics will be produced in satisfactory form in the future.

# How Glass Reflectors Are Made Through Vaporization of Aluminum

***Aluminum is chosen as a reflector material because of high reflectance, resistance to oxidation and because it can be simply applied.***

**by KENNETH ROSE, Western Editor, Materials & Methods**

IN CERTAIN TYPES OF LAMPS it is of considerable value to direct the energy instead of permitting it to be radiated in all directions from the source. Infra-red lamps, for instance, gain in efficiency if the rays produced at the filament can be concentrated upon a field in front of the lamp, instead of having a large part of the rays fall upon objects at the sides or toward the rear of the lamp. This effect was obtained in part in the earliest lamps by using outside reflectors, usually of parabolic form to obtain a beam of the reflected portion of the energy.

Outside reflectors, while quite efficient in most applications when new and clean, tend to lose efficiency rather rapidly as the reflecting surfaces tarnish, or as dust accumulates on them. For this reason a new type of reflector has become important. Building a reflecting film over the inside surface of the envelope of the lamp greatly reduces the rate of deterioration of the reflector, and eliminates such chores as cleaning the reflectors. They have won acceptance not only for infra-red lamps, but for many other types, such as sealed-beam headlights for automobiles, spotlights,

*A finished reflector is taken from the bell jar after the glass surface has been aluminized.*

lamps to illuminate store-window and showcase displays, and novelty lighting.

Aluminum is the metal selected for these internal reflectors, partly because of its excellent resistance to oxidation and its high reflectance, and especially because it lends itself to a rapid, simple method of application. Reflectors can be made from many metals by careful polishing, and glass can be made reflective by mirrorizing one of the surfaces, the smoothness of the glass substituting for the laborious polishing that must be performed upon metal surfaces when used alone. Either method is time-consuming and difficult to adapt to mass-production methods. By using aluminum, the metallizing of the glass surface can be accomplished by vaporizing the aluminum and condensing it on the surface to be mirrorized. Actual deposition of the metal requires only a few seconds, and the preliminary operations are not complicated, nor do they require elaborate apparatus. Equipment for the metallizing of the lamps is quite simple.

Westinghouse Electric Corp., General Electric Co., Guide Lamp Div. of General Motors Corp., Sylvania Electric Products Co., and several of the manufacturers specializing in infra-red lamps use essentially the same procedure in production of lamps with internal reflectors. The detailed procedure given here is that used at Sylvania Electric Products Co. plant at Salem, Mass., and the pictures supplied illustrate the operations at that plant.

First operations are concerned with cleaning and preparing the glass envelopes of the lamps. They are:

(1) Hot water rinse.

(2) Hot rinse with alkaline cleaning compound.

(3) Hot water rinse.

(4) Etching rinse with hydrofluoric acid. The acid used is of a strength varying between 3 and 15%, the weaker acid causing an almost imperceptible etch on the surfaces to permit better adherence of the metal film, while the stronger acid is used to obtain a slight "frosting" of the window.

(5) Hot water rinse.

(6) Second rinse with hot distilled water. This is necessary because of the high content of organic matter in the local water supply at certain seasons of the year.

(7) Hot air drying.

After the lamp bulbs, or envelopes, are cleaned and etched, the actual metallizing operations begin. The sequence of these steps is as follows:

(1) Preliminary drying. The bulbs are again dried in warm air to remove any traces of moisture that may have condensed in them during storage.

(2) Placing on aluminizing head and pumping to high vacuum. Pumping is done in two stages.

(3) Low-voltage current applied. This treatment heats the aluminum slug in the aluminizing head to incipient fusion.

(4) High-voltage current applied to vaporize aluminum.

(5) "Setting" of the film. The bulbs are removed from the aluminizing heads and heated with infra-red heat for 3 to 5 min. to "set" the aluminum coating. An extremely thin oxide film is formed in the course of this setting, and makes the film less liable to excessive oxidation later on. It also sharpens the line of "cutoff" obtained in the next step.

(6) Removing part of the film to form the window. As a clear window is required at the front of the lamp, the film is dissolved at that area. A weak caustic solution is run into the bulb as it stands in an upright position in a frame, and the aluminum film immersed in the caustic is dissolved in about 2 to 5 min. A little alcohol is added to the caustic to decrease the surface tension of the solution, and so to improve wetting. The solution is run into the bulb through a tube that extends nearly to the bottom of the bulb, and so contacts only that part of the film that is to be removed. After the aluminum has been dissolved the solution is siphoned out, the bulb being maintained in an upright position during the entire procedure with the caustic solution.

(7) Warm tap water rinse. The water is pumped into the bulb, diluting the few drops of caustic solution remaining, and the bulb is then removed from the frame and the warm rinse-water poured out.

(8) Spray rinse. The bulb is inverted over a spray head and rinsed, first just above the caustic line, then over the whole interior surface.

(9) Air drying.

(10) Inspection.

The metallizing operation is extremely simple. A commercially pure aluminum, 99+% pure, is used, either as a crimped strip or as wire. For most types of lamps the aluminum is used as a crimped strip, the quantity carefully matched to the area of the bulb to be coated, but of the order of 0.01 oz. for average sizes. The aluminum slug is placed in a small coil of tungsten wire, about ½ in. in dia., on a support that provides a collar of Neoprene rubber against which the neck of the lamp bulb can be fitted. The cleaned bulb is placed over this aluminizing head, the neck fitting snugly around the synthetic rubber gasket, and the first stage vacuum pumps "rough out" the air.

Positive displacement pumps are used for the first stage evacuation. These are succeeded by oil diffusion pumps, which take the vacuum down to 1 to 5 microns of mercury. To guard against flying glass in case of implosion, a clear plastic shield is placed over each bulb as the evacuation is begun.

Low-voltage current is applied to the apparatus to degas the aluminum, and to increase contact with the tungsten coil so as to eliminate the danger of arcing or spattering when the flashing current is applied. Low heat is continued for about 10 sec. The current applied is just sufficient to heat the aluminum to the softening point, without actually melting it.

At the end of the period of low heat, the current is switched directly to high heat, and the aluminum is immediately volatilized. The vapors condense on the inner walls of the bulb down to a cut-off disk that fits loosely inside the neck of the bulb. A current of 60 to 125 amp. at 15 to 25 v. is used for flashing.

Certain variations of the process make it adaptable to other types of lamps in which the internal reflector is desirable. For small lamps it is economical to place many of the bulbs on a rack and to enclose rack and bulbs in a bell jar, sealed at the bottom with a rubber gasket, and connected to vacuum pumps so that the

***Elements involved in aluminizing reflectors include the reflector, a heavy tungsten filament, crimped aluminum and a bell jar. (Photos: Courtesy General Electric Co.)***

entire jar can be taken to high vacuum. In the production of show-case lamps the aluminum is used in the form of wire, threaded over supports along a tungsten filament, and applied to one side of a plate that serves to shield half of an elongated bulb longitudinally. No other cut-off is required. Forty-eight bulbs are placed on each rack, evacuated simultaneously under a bell jar, and flashed simultaneously also.

Another technique used with large lamps is the bead cut-off, in which the portion of the bulb that will constitute the window is filled with small glass heads, an aluminizing head inserted in an inverted position, and the aluminum vaporized as before. The beads protect the window from the metal vapors, so that no chemical solution of the aluminum at that point is necessary.

A type of lamp made by General Electric Co. and Westinghouse Electric Corp. uses glass reflectors that are metallized and afterward hermetically sealed to the lenses to complete the lamp. These are widely used as sealed-beam automobile headlights. General Electric uses an automatic 16-station machine in which a circular table with fixtures revolves to carry each fixture in turn through stations at which a high vacuum is built up, then to a firing station at which the aluminum is vaporized, then through three more stations to provide for release of the vacuum, and finally to the loading-unloading station, where the reflectors are removed.

The fixtures are rings to which the reflectors are attached, face to face, and sealed against synthetic rubber gaskets. A tungsten wire coil holds the crimped strip of aluminum. As the table turns, each station is indexed so that air is exhausted from the fixture by vacuum pumps. When the firing station is reached, a high vacuum has been built up in the fixture, and firing takes place automatically at electrical contacts at the station. After release of vacuum and unloading of the metallized reflectors, the tungsten filaments and bases are fitted to them, lenses are placed over the reflectors, and the whole is sealed hermetically by gas flames. Air is removed from the lamp through a tubulation, and an inert gas is introduced to replace it, after which the tubulation is sealed off, and the lamp is complete.

Aluminum is used for internal reflectors in all lamps of this type for the following reasons:

(1) Aluminum has excellent reflectance for most of the wave-lengths of energy used. It reflects approximately 80% of such energy.

(2) It is resistant to corrosion, and so is not greatly dulled while in storage before the final lamp-making processes.

(3) Because of its ready affinity for oxygen, it serves as its own "getter" during metallizing.

(4) Its low melting and boiling points make it easy to vaporize.

While aluminum is the reflecting metal in all important commercial lamps of this type, other metals have been tried. Brass and copper were considered for sealed-beam fog lights, but were found to have no great advantage when tested. Silver, brass and copper have been vaporized for reflectors, and, while the vaporization can be accomplished, the lamps show no advantage that would make them commercially practicable.

Lamps with internal reflectors are used in such applications as sign lighting, for down-lighting in industrial and other fields, flood-lighting, for spotlights, railroad headlights, automobile sealed-beam headlights, show-case lamps, for infra-red lamps with directed beam, and for novelty effects.

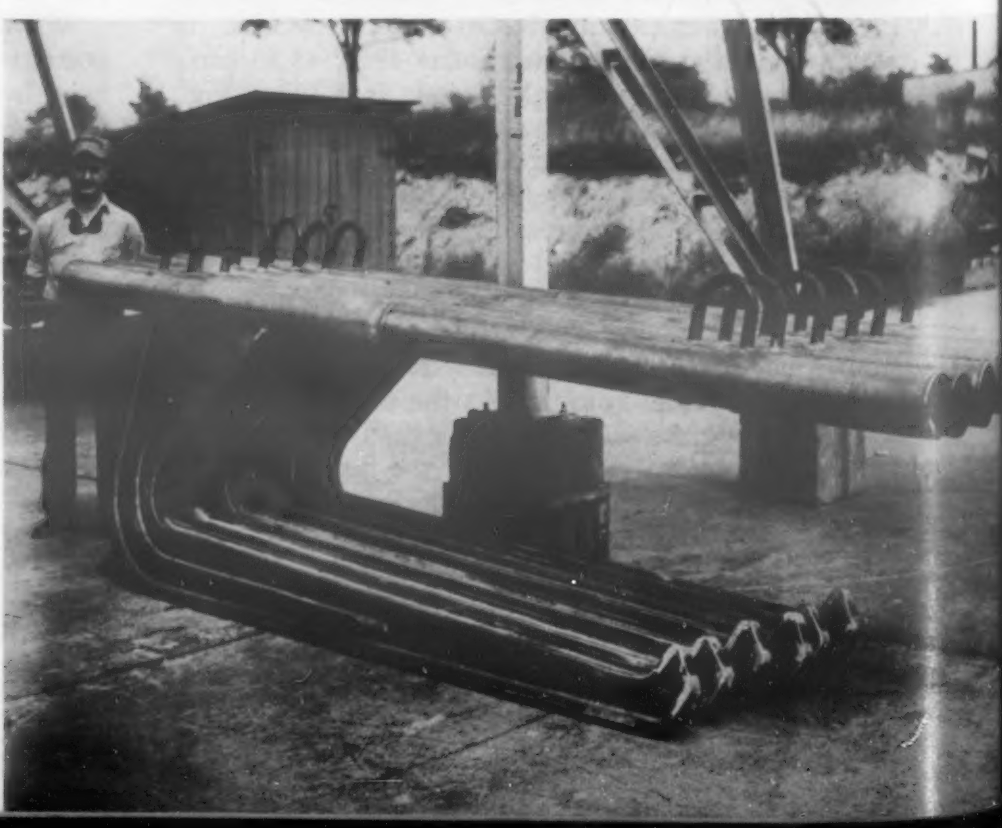
# Materials at Work

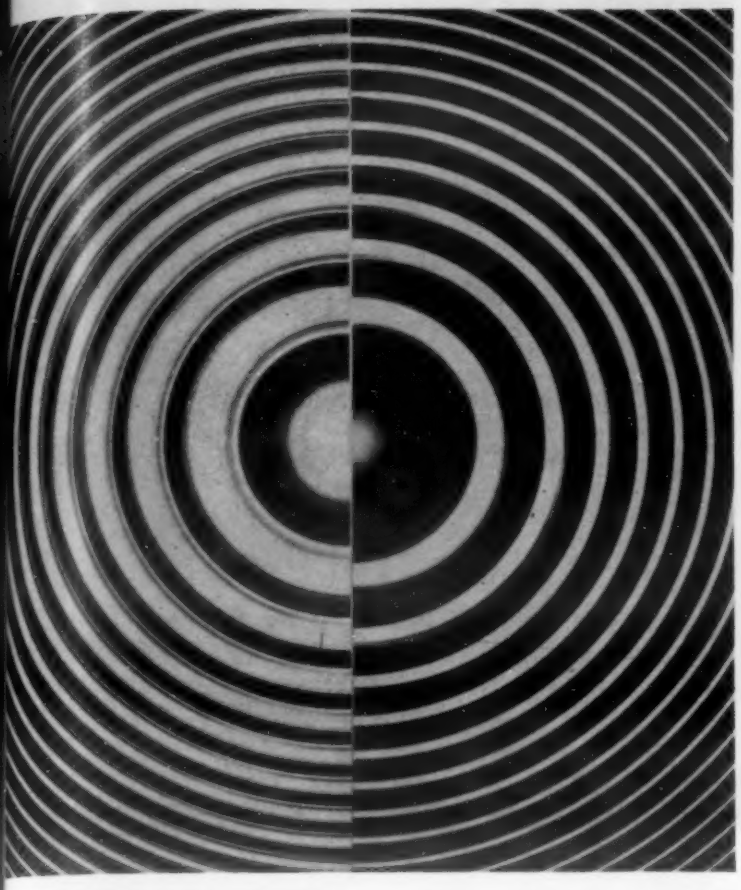
**ALL-METAL DOOR MAT** *Formed of aluminum stampings, aluminum alloy rods, and die cast zinc spacers, this unusual door mat is produced by the Ability Die Casting Co., Chicago, Ill. The mat consists of three sections which fold together. The stamped aluminum strips in each section are so spaced that when folded, a scissor-effect removes mud or other material from the mat. The spacers are cast 20 to a "shot" and removed from the gate in a trimming fixture. Special jigs position the units for rapid assembly.*

***Here is materials engineering in action . . .***
***New materials in their intended uses . . .***
***Older, basic materials in new applications . . .***

**NICKEL-COPPER ALLOY PICKLING HOOK**

*Welded of heavy Monel plate, these six hairpin hooks weigh 1272 lb. each and are capable of carrying loads up to 4200 lb. The round supporting members are of steel covered with a welded-on jacket of 14-gage Monel. The hooks were designed and made by the Youngstown Welding & Engineering Co. for pickling of wire and cable.*



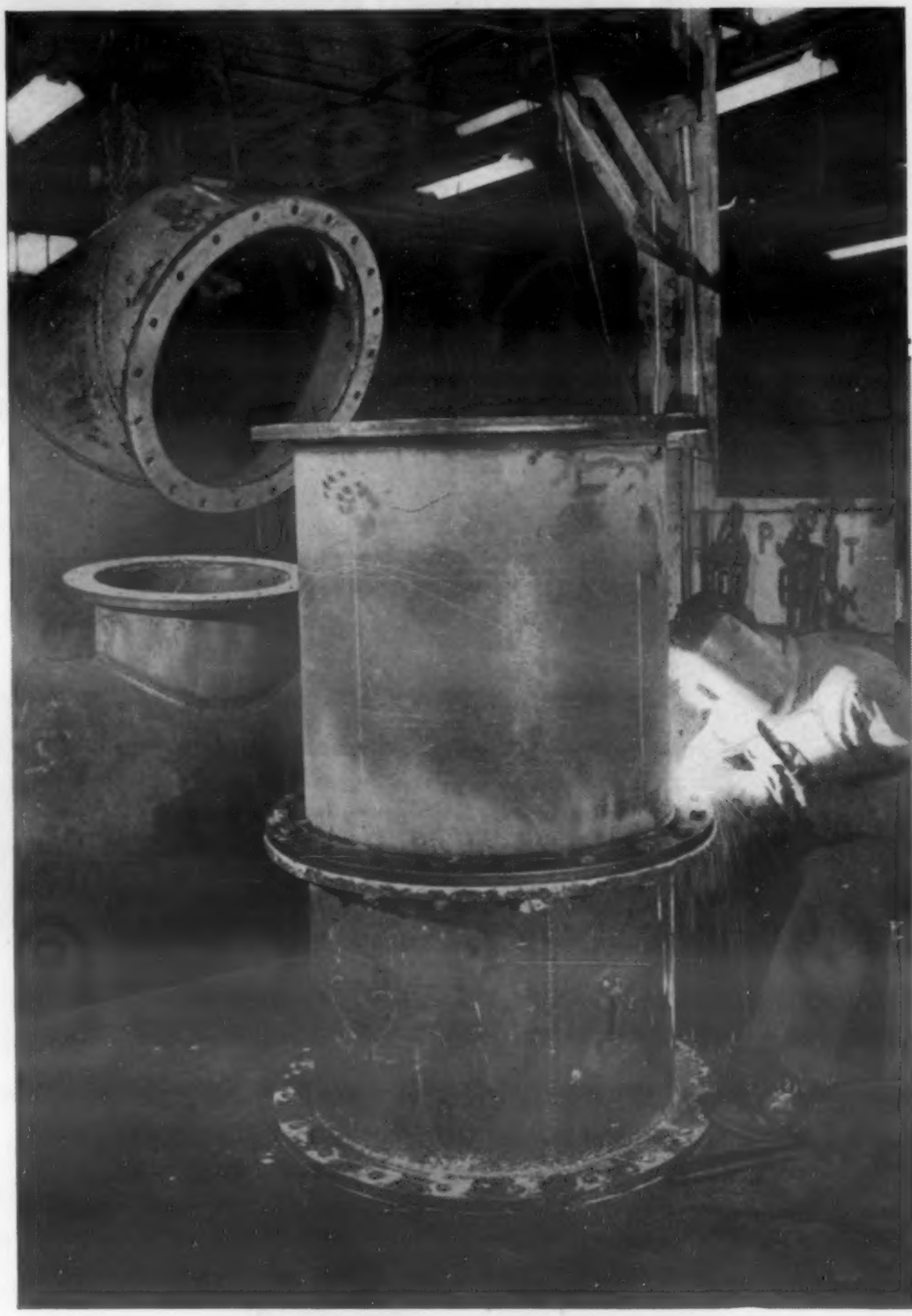


## MERCURY FRINGES

*Providing a new and better standard of length, the wave length of the green radiation of mercury isotope 198 represents the ultimate in sharpness and intensity obtainable from any atom. The interference fringe of mercury 198, a stable isotope made by bombarding gold with neutrons in an atomic pile, is compared in the photograph (right) with the fringe formed by the green radiation of natural mercury (left). From these fringes, the wave length of $Hg^{198}$ radiation has been measured with an accuracy of one part in a hundred million. One part in a billion is theoretically possible. Radiation is obtained by exciting a few milligrams of $Hg^{198}$ with high-frequency radio waves.*

## FLAT PLATE WELDED FITTINGS

*Difficulty in obtaining cast iron welded fittings of the type required for a natural gas line forced the Akweld Construction Co., Brooklyn, N. Y., to make up the fittings from flat steel plate. Sections were first cut from ¼-in. and 5/16-in. stock with an Airco No. 10 Radiograph oxyacetylene cutting machine and then rolled into shape. The fittings ranged from 8 to 50 in. in dia. Butt joints were welded from both sides and flanges were welded both inside and out. Flanges were backed up to control distortion during the welding operations.*

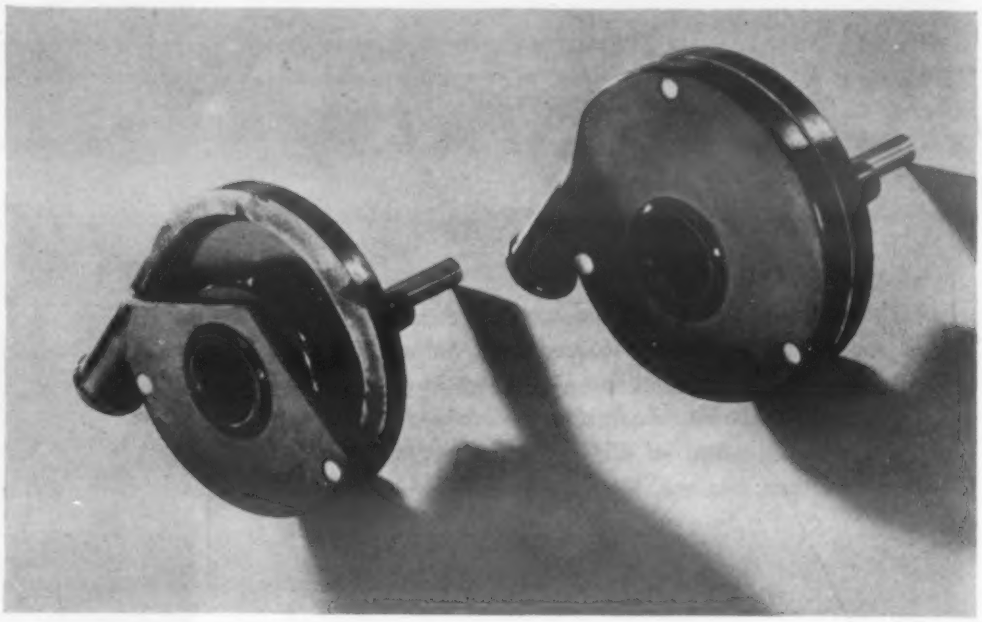


## DENSIFIED WOOD SPINNING CHUCKS

*Machined from compressed wood veneers impregnated with Bakelite phenolic resin, these spinning chucks provide major economies in spinning aluminum parts. Production cost is approximately one-sixth that of similar forming dies made of metal, and their low coefficient of friction prevents overheating of the metal being worked. The chuck material, known as densified wood and produced by Parkwood Corp., Wakefield, Mass., has great wear and abrasion resistance. It takes a permanently smooth finish and does not scratch the aluminum part being spun.*

# Materials at Work

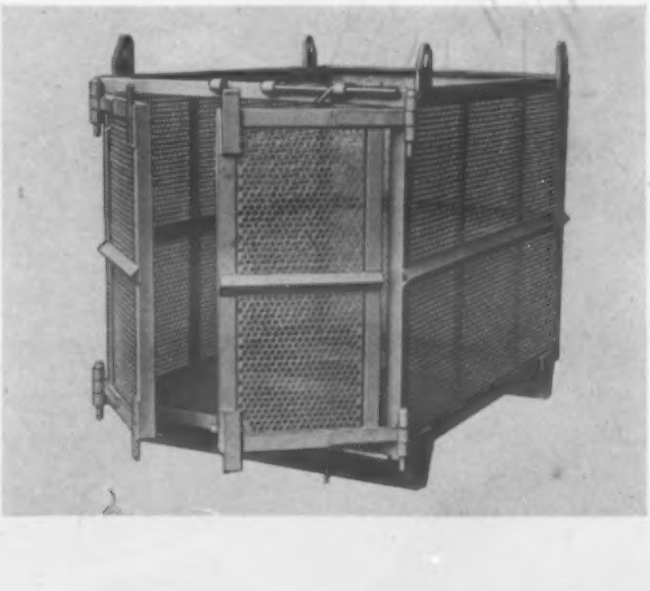
**NAILABLE STEEL FLOORING** *Curved-flange steel channels, separated by grooves into which ordinary nails can be driven, are the latest innovation in freight car flooring. Gondolas are customarily equipped with either wood floors or conventional steel plate floors, depending on their use. This new nailable steel flooring, developed by the Great Lakes Steel Corp., Detroit, Mich., permits all cars so equipped to handle both the finished goods which must be blocked in place by nailing to the floor and the rough materials which require the strength of steel flooring. The nailing grooves are filled with plastic to prevent loss of fine freight carried in bulk.*



**PHENOLIC PUMP PARTS** *To lessen danger of liming or clogging, the enclosed-vane impeller and casing of a small fluid circulating pump are molded of Durez phenolics by Broadbent-Johnston, Inc. Both parts are molded in halves and joined in assembly with liquid phenolic resin. The four parts come from the molding press with a high-gloss finish to minimize fluid friction. The slight flash formed at the mold parting line is removed before the halves are joined.*

**TUNGSTEN-NICKEL-COPPER ALLOY** *Originally developed as a screen against radium rays, this new alloy is produced by the General Electric Co. under the name G-E Hevimet. Its density is 50% greater than that of lead. Composition includes 90 tungsten, 6 nickel and 4% copper. The high tensile strength (85,000 to 118,000 psi.), good fabricating properties, and high corrosion resistance of this alloy make it suitable for applications requiring maximum inertia and minimum size. The gyroscope rotors illustrated are an example of this alloy's use.*

**HIGH-STRENGTH LOW-ALLOY IMMERSING BASKET** *The high-tensile, corrosion-resisting properties of this steel immersing basket provide positive resistance to acid pickling solutions. The basket, fabricated of Cor-Ten by Phillips Mine & Mill Supply Co., is easily conveyed by crane or fork lift truck. Heavy duty construction assures long, continuous use.*



# ATERIALS & METHODS MANUAL

# 44

This is another in a series of Manuals on engineering materials and their processing published as special sections in Materials & Methods. Each manual is complete in itself and is intended to serve as a reference book on the subject covered. These manuals provide the reader with useful data on characteristics of materials or fabricated parts, and on their processing and application. Preceding manuals have taken their places in the permanent reference files of thousands of readers.

# Mechanical Tubing as an Engineering Material

by H. R. Clauser, Associate Editor,
Materials & Methods

Mechanical tubing is a basic metal form manufactured specifically for further processing into fabricated parts. Its advantages of inherent structural strength, weight saving, and reduction of production time and costs make it attractive to the engineer for the design and production of a wide variety of products. This manual outlines the types and shapes of mechanical tubing that are available, the ways in which it can be worked and fabricated, and some typical applications. It also gives the principal characteristics and properties of the many different tubing materials.

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December 1948

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# Introduction

Mechanical tubing is a versatile, basic metal form from which a wide variety of of products can be fabricated. It offers many advantages to the engineer in the design and production of items ranging from tiny watch pinions to gas cylinders and even larger products. Some of the important advantages of tubing are savings in weight, inherent structural strength, and reduction in fabricating time and costs, particularly in machining operations. For some parts, such as relatively long, thin-walled cylindrical objects, tubing is the only answer. On the other hand, there are many uses —for example, bushings, metal washers, and a variety of cylindrical shaped objects —in which tubing often competes with bar stock, punchings, machined parts, welded parts, and castings.

The word "tubing" is sometimes used to describe several different tubular products, such as pipe and casing; however, it refers more specifically to seamless or welded tubular forms which are manufactured to closer size tolerances than pipe. Another distinction is that practically all pipe is round in section while tubing is available in a variety of shapes and also in most metals and alloys that can be formed.

Besides mechanical tubing, there are two other principal types of tubing—pressure and structural. Pressure tubing is used to convey liquids or gases under pressure; it will not be covered in this manual. Structural tubing is used primarily for structural purposes and will not be covered specifically here. However, in most cases mechanical and structural tubing are one and the same product, and the distinction rests only upon the application. And even here, the distinction is often not clear-cut because many fabricated tubular parts serve also as structural members.

*(Courtesy: Joseph T. Ryerson & Son, Inc.)*

# Characteristics of Mechanical Tubing

From what has already been said, it is evident that mechanical tubing is manufactured specifically for further processing into fabricated tubular products. It is of uniform and high quality, and produced to close tolerances. In addition, it usually has good machining qualities, relatively high finish, and is available in a wide range of materials, analyses, shapes and sizes.

## Materials, Types and Shapes

The principal materials in which mechanical tubing is produced are carbon, alloy and stainless steels, copper alloys, aluminum and its alloys, magnesium alloys, and nickel and nickel alloys. In addition, specialty tubing is made from a number of other, less common materials.

Tubing of most materials is furnished in a number of different conditions or tempers to meet specific forming or service requirements. It is also normally available in at least one or two standard finishes. The finishes, of course, depend upon the material and methods of manufacture. Where required, any one of a variety of special finishes can be had on order. For example, it can be obtained with special inside surface or special outside surface, or both. For applications such as plating and those requiring exceptionally smooth uniform surfaces, the tubing can be furnished ground and polished.

Tubing is produced either in seamless or welded form. Seamless tubing, as the name indicates, has no longitudinal seam; however, for a few applications, seamless tubing is joined end to end and therefore has a circumferential seam. Welded tubing is manufactured from flat stock and has a longitudinal seam. Some of the materials mentioned above can be produced in only seamless or welded tubing, while others can be produced in both forms.

Seamless and welded tubing are alike in many of their characteristics, while in others they differ. The choice between the two, therefore, depends upon the requirements of each application. Welded tubing is made with relatively thin walls and so is available in a limited range of wall thicknesses. Seamless is produced in a larger range of sizes and wall thicknesses, including heavy walls. Since welded tubing is made from flat rolled stock, somewhat closer wall thickness tolerances can be maintained than with seamless. Welded tubing is available in only those materials and grades of material that are weldable.

In mechanical properties, as-welded tube is about equal to the flat stock from which it is formed. Its properties are generally lower than cold drawn seamless tubing because of the improvement in properties resulting from cold work. However, drawn welded tubing approaches the properties of seamless. Both welded and seamless tube are closely comparable in their forming characteristics. Where performance requirements can be met, welded tubing (as-welded), in general, will be somewhat more economical than seamless.

One of the big advantages of mechanical tubing is that it can be obtained in a wide variety of sizes and shapes. In many cases, by proper design of the part and careful selection of tubing, machining and other shaping operations can be cut to a minimum.

The most common and widely used shape of tubing is the round section. There are, however, many other cross-sectional shapes that are available to meet specific problems. Square and rectangular sections are produced as standard shapes by most tube producers, and are available in a wide range of sizes. In addition to these, many producers manufacture other shapes which they have available in a regular range of sizes. The following are some of the special shapes that can be produced on order: Embossed; fluted outside, plain inside; fluted; hexagon; lip; octagon; pinion (longitudinal serrations on outside); polygonal outside, round inside; reeded outside, plain inside; reeded; roped; rope-fluted; rope-reeded; round outside, polygonal inside; and twisted.

## Tolerances

As pointed out before, a distinguishing characteristic of mechanical tubing is the close tolerances to which it is produced.

In extremely small sizes, for example, tolerances on the cross-sectional dimensions, can often be held to ±0.002 in. These close tolerances facilitate fabrication in a number of ways and cut production costs.

Round tubing has three cross-sectional dimensions which must be considered in ordering and fabricating. They are the outside diameter (O.D.), the inside diameter (I.D.), and wall thickness or gage. In seamless and drawn welded tubing each of the dimensions may vary independently; therefore it is important to have a knowledge of the tolerances to which the tubing is manufactured. The O.D. tolerance (and I.D., when specified) is commonly given as a definite permissible variation in thousandths of an inch. Wall tolerance, however, is often given as a percentage of the specified wall.

Because of manufacturing limitations, drawn and extruded tubing is not always truly concentric. The distance off-center between the O.D. and I.D. is termed eccentricity and is reflected in variations in the wall thickness. It has no effect on the O.D. or I.D. The variation in wall thickness is of particular importance when the tubing is to be machined. Enough stock must be allowed for the tool cut on both surfaces, plus an allowance for the maximum eccentricity which is reflected in the wall thickness.

Tubing also usually has a certain amount of ovality. This is the difference between the maximum and minimum diameters of any one section of the tube. Ovality of seamless tubing depends upon several things, including temper, wall thickness and straightness.

## Applications of Mechanical Tubing

Tubing offers a number of inherent advantages, not found in other metal forms, that suit it to a wide range of applications. Most parts of a general cylindrical or ring-shape can usually be made more efficiently from tubing than from bar stock, because by using tubing the part is already partly fabricated.

Particularly in the field of machined parts tubing offers many advantages, such as a saving of weight and reduction in machining time and costs. Applications where tubing is particularly suited are for long parts requiring deep drilling, and for parts having large outside diameters and relatively light wall sections.

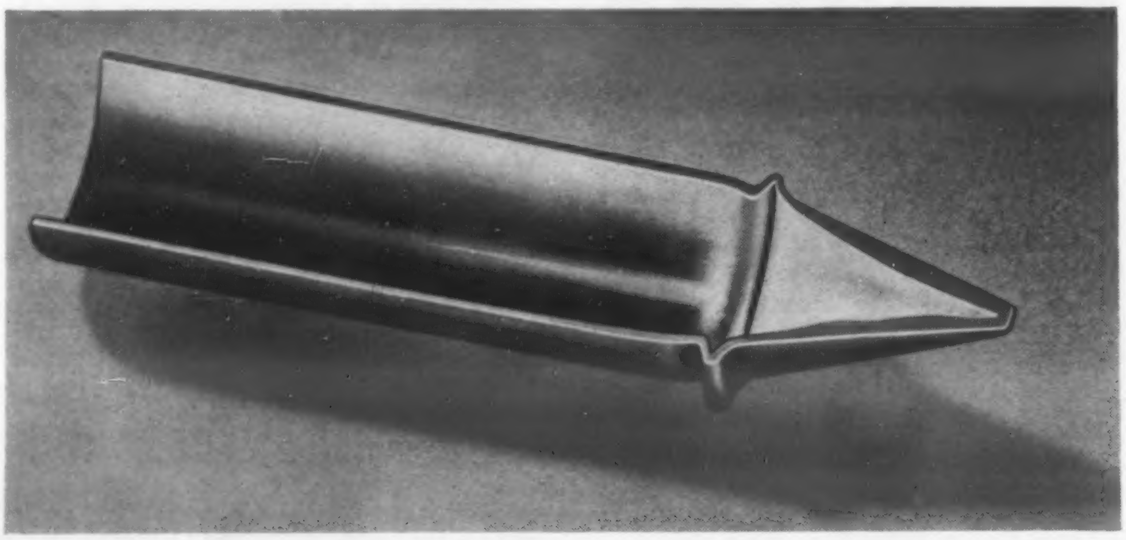
The cost of tubing is in many cases higher than bar stock, but the savings in processing often offset any additional material cost. Thus, drilling operations can be eliminated, and drills replaced by simple, less expensive boring tools. Boring can be done faster than drilling; chucking pressures are reduced. There is also less tool wear and fewer tool changes. In many cases additional tooling positions are made available by the use of tubing. With multiple spindle automatic screw machines, many parts can be machined two or more per cycle instead of one per cycle.

The field of use of tubing is extended by its ability to be worked and fabricated into parts by many other methods. These forming methods will be described in the next section of this manual. With these methods tubing serves as a semi-finished form which is further shaped into the finished product. In many applications the forming is of such a nature that the tubing practically loses its identity as such. Here are but a few typical applications of fabricated tubular parts: bearing races, bushings, lathe spindles, cylinders, containers, hypodermic needles, axle housings, sporting goods, housing assemblies, and gun parts such as magazine tubes, magazine clips, and receiver sections.

Five outstanding applications of mechanical tubing are shown and described in more detail in the accompanying illustrations.

In addition to the types of applications mentioned above, tubing is frequently used to serve as a load carrying member or part, because it has a number of structural advantages over other metal forms. For a given weight, a tube provides the best section under practically all load conditions, and will carry more load than any other section. Where a part must withstand equal loading in any direction, a tube offers the best cross-section. Tubing has superior bending qualities, because it can resist bending stresses equally in all directions. Also, in parts subject to shock, tubing has the quality of tending to absorb and localize the shock. Under dynamic loading a tubular section provides higher rigidity, and has a higher frequency and smaller amplitude of vibration. Finally, in torsion, round tubing provides the best material distribution, and for a given weight can withstand more load than other sections.

A few typical applications that make use of these structural advantages are automotive transmission shafts, drive shafts, spline shafts, aircraft struts and other airplane structural members, furniture, and framework for buses and trucks.



***The old way of fabricating this tripod leg, a section of which is shown here, involved two pieces of brass tube, a brass rod and a brass casting. Now the part is produced from a single piece of brass tube by spinning the end to a point and forming the bead in a punch press. The results are savings in material, lower cost, less weight, and more durable construction. (Courtesy: Wolverine Tube Div.)***

# Forming and Fabricating Methods

One of the reasons why tubing has such a wide range of uses is its adaptability to a variety of forming methods. The most commonly used methods are briefly described below, and some idea given as to the shapes into which tubes can be formed.

*Bending*—This is the most common method of forming tube. In bending operations the outside of the bend is stretched, and the inside is compressed, so that buckles or wrinkles tend to form on the inside bend. Therefore, there are limits to which tubing of any given material can be bent, depending upon the size, gage and condition of the metal. The minimum radii without distortion to which a tube of a given material can be bent depends on wall thickness and tube diameter. For light gage work, a mandrel must be used to prevent buckles.

There are two methods of bending tube. One is bending without a mandrel, often called press bending; the other is bending with a mandrel. Bending without a mandrel is the cheaper of the two. The tools are inexpensive and can be used over a wide range of angles. Also, the operation is rapid. With some exceptions press bends are used on steel tube when the outside diameter of the tube does not exceed 2½ in., and the angle of the bend does not exceed 90 deg.; when the outside diameter exceeds 2½ in., the angle of bend must not be greater than 75 deg.

A better grade of bend is usually obtained by using a mandrel. The tools, however,

are more expensive and the operation is slower. The equipment consists of a bending die and mandrel holder, with the necessary jaws and clamp to grip the tube while being bent. This method is used when the metal must be kept smooth, or where a minimum reduction in diameter in the vertical plane is desired.

*Swaging*—By swaging, the diameter of a tube can be reduced for part or all of its length. The reduction is accomplished either hot or cold, depending on the metal, by a series of blows with a rotary swaging machine, power hammer or hydraulic press. If it is done cold the swaged tube often needs a subsequent annealing to relieve the cold work stresses.

The wall thickness of the swaged portion will usually be thicker than that of the original tube. No definite rules for the amount of reduction can be given; however, in general, a given percentage reduction in diameter will give approximately the same percentage increase in wall thickness.

Tapering of tube is also done by a swaging process. Tapering is more expensive since it requires accurate dies that will be in line and properly matched during the swaging operation.

*Spinning*—Spinning is a popular and versatile method for shaping tube. One method involves rotating the tube at high speed with a forging tool or roll held against it, shaping it to the desired form. Another method is to hold the tool stationary and rotate the tool. Spinning can be done hot or cold. When done cold the heat generated by friction between the tube and tool facilitates the forming operation. In hot spinning, the portion of the tube to be spun is heated to the forming temperature and then the forming tool is forced against the work. Hot spinning is somewhat faster than cold spinning.

Practically all tube materials and tube sizes can be spun by either the hot or the cold method. One of the principal uses of spinning is to close the ends of the tubes. By proper manipulation of the forming tool, any one of a variety of shaped closures, such as flat, pointed and spherical, can be obtained. Spinning is also used for reducing the size and shaping portions other than the ends of tubes.

A modified cold spinning method, known as the Dewey process, can shape a straight piece of tube into varying contours. In this process, the tube while rotating is pulled through a forming unit and is shaped by a free turning forming roll. The operation is usually performed in one pass. The spun tube is circular in all cross sections. Long pieces of tube can be pulled through the machine and the same contour shape over a short section of the tube can be repeated. Later the tube can be cut up into individual pieces all having the same configuration.

*Upsetting*—In upsetting, the wall of the tube at the end or ends is thickened. Tubes can be upset either on the outside or the inside of the tube. The operation on some materials, such as copper alloys, is sometimes performed cold, while on others, like steel, the tube is heated locally on the end to be processed and then upset in a forging machine. The amount of upsetting that can be done depends on the material. For example, steel tube from 1 to 5 in. O.D. with ⅛-in. wall thickness or heavier can be upset as follows: The wall of the upset cannot exceed 1.8 times the original wall thickness and the length of the upset cannot be longer than 15 times the original wall thickness, nor can it exceed 4 in. in length. The inside diameter of the upset cannot be less than ⅜ in. These limitations are based on common commercial practice, but longer and heavier upsets are possible; also, larger diameter tubing than that given above can be upset.

Flanging, in which a flange or lip is formed on the end of the tube, is a modification of the outside upset operation. It is more severe and usually requires more than one forging operation.

*Flaring*—Flaring is a forming operation that widens the end of a tube to a funnel shape. The degree and amount of flaring possible on any given tube material depends upon the wall thickness, ductility and temper of the tube. Flaring can also be used under certain conditions to flange tubing.

*Expanding*—Expanding is similar to flaring but differs from it in that the enlarged end is parallel to the tube axis rather than being spread out like a funnel. As in flaring the amount of expansion possible depends upon the dimensions, ductility, and condition of the tube. It can be done either hot or cold.

*Flattening and Sealing*—Flattening and sealing is a relatively simple operation accomplished in a press. For sealing, the tube can be either pinched flat or crimped into a "W" shape. Flattening generally involves pressing the end of the tube flat without closing the tube end, as is the case in sealing.

*Beading and Grooving*—This is done simply by forcing the tube against rolls. Either raised beads or grooves are possible. The width and depth of the beads or grooves can be varied to produce configurated tubes. The amount of formings possible depends on materials, properties and wall thickness of tube.

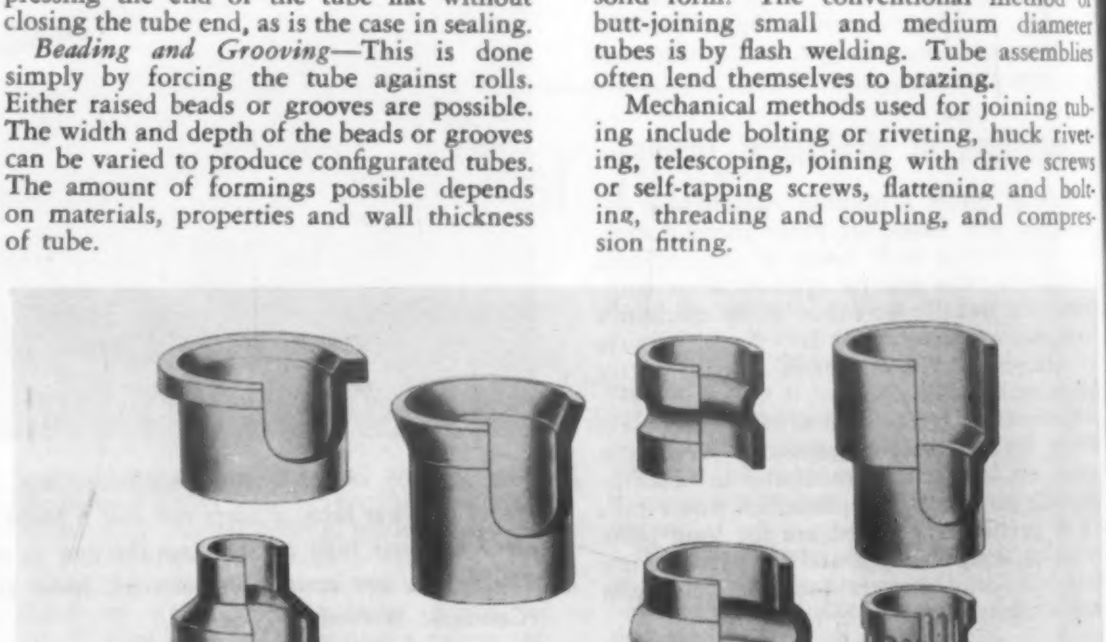
*Machining*—Since machining is one of the most frequently used methods of producing parts from tube it is important to consider the characteristics that influence tube machining operations. All three cross-sectional dimensions—wall thickness, inside and outside diameters—must be considered when tube stock is machined. So in selecting tube that is to be machined, three factors must be considered: (1) Variations from nominal dimensions must be taken into account to allow enough stock in the tube for the tool cut on both surfaces. (2) The method of chucking must be considered because it determines whether any eccentricity in the tube will be reflected in the O.D. or the I.D. (3) The amount of stock that is to be removed should be provided for in the tube.

The machinability of the various tube materials is about the same as that of solid stock on the same material. And, in general, the same equipment, such as lathes, single and multiple spindle semi-automatic and automatic screw machines are used.

*Drilling and Piercing*—These operations are generally done on a punch press, by using a supporting arbor inside the tube. Light walled tube is usually pierced while heavy walled tube is drilled. Drilling produces burrs on the inside tube surface and if necessary must be removed by reaming.

*Joining*—Tubing can be assembled by all the common welding and mechanical joining methods. The weldability of a given tube is the same as that for the metal in solid form. The conventional method of butt-joining small and medium diameter tubes is by flash welding. Tube assemblies often lend themselves to brazing.

Mechanical methods used for joining tubing include bolting or riveting, huck riveting, telescoping, joining with drive screws or self-tapping screws, flattening and bolting, threading and coupling, and compression fitting.



*Tubing can be worked and fabricated by a wide variety of methods. Shown here are a number of the common shapes into which tubing can be formed. (Courtesy: Republic Steel Corp., Steel & Tubes Div.)*

# Steel Tubing

Mechanical steel tubing is divided into two main classes—seamless and welded—and each of these is further subdivided according to the methods of production and finishing.

*Each half of this rear axle housing was formerly made of two pressed steel parts joined by resistance welding. Its manufacture has now been simplified by adopting welded steel tubing. Each half is made from a 4½-in. O.D. welded tube reduced approximately 35% in dia. The one end is hot upset and flanged, increasing wall thickness about 50%. The opposite end is shaped to a half-circle channeled "banjo" section with a dia. 2¼ times the original tube diameter. (Courtesy: The Standard Tube Co.)*

## Seamless Steel Tubing

There are two methods of producing seamless tubing. The one most used for mechanical tubing involves hot piercing solid steel billets or bars and reducing the size by either hot rolling or hot drawing, or by a combination of both. In the other method, steel plate is hot cupped and then hot drawn to size. Hot cupping is seldom used for sizes under 9 in. The tube, if used in either of these two conditions, is known as hot finished tube. Its surface finish is like that of other hot rolled steel products.

To produce mechanical tubing of greater accuracy and in smaller sizes, the hot worked tube is further processed by drawing through a die and over a mandrel, thus reducing outside and inside diameter as well as the wall thickness. This is known as cold finished tubing. It has closer tolerances and a smoother surface finish than the hot finished type, and also greater strength and improved machinability. The cold drawing operation is often repeated a number of times to reach the final dimensions, and in such cases the tube is annealed between passes to remove cold-working stresses.

Seamless tubing is available in practically every commercial grade of steel, including carbon, alloy, and stainless steel grades. It can also be had in special analyses to meet specific service requirements. Listed in an accompanying table are a number of representative grades of steel from which seamless tubing is made. Also in the table are listed a few important mechanical properties of these steels. Properties for both hot finished and cold finished seamless tube are given. It will be noted that the strength properties of the cold finished tube are considerably higher than for the hot finished type.

Seamless mechanical tubing can be fabricated by practically all the common forming methods listed earlier in the manual. However, cold drawn tubing, in the finished anneal condition, with its moderate ductility cannot undergo severe forming operations while cold, and so should be soft annealed for maximum workability.

While the machinability of low carbon seamless tube in the finish annealed condition is not equal to that of screw steels and other free cutting bar stock, it is suitable for all cutting operations and relatively good machining results can be obtained. For screw machine work or where a large amount of machining is required, tube of a free cutting grade such as AISI 1118 is usually recommended. Machinability improves with cold work; therefore hard-drawn tube shows the best machinability.

Cold drawn seamless tube is most generally furnished in the finish annealed condition. However, it can be had in other conditions to meet specific physical requirements. The common heat treatments or conditions in which the finished tube are available are unannealed, soft annealed, medium annealed, normalized, finish or stress relief annealed, and hard drawn.

Seamless tubing is available in a wide range of standard diameters and wall thicknesses. Hot finished tube ranges in outside diameters from 1½ in. to 10¾ in. and in wall thicknesses from 0.095 in. to 2 in. Cold-drawn tubes are produced in standard sizes ranging from 3/16 in. O.D. by 0.035 in. to 10½ in. O.D. by 1 to 2 in. wall thickness. Specialty tubing can be produced in extremely small sizes. An accompanying table gives the tolerances obtainable on standard sizes. Although the standard and most used shape of seamless tubing is round, other special sections are readily available.

The surface finish of seamless tube depends primarily on the method of manufacture. As was pointed out previously, hot-finished tube has a rougher surface finish than cold finished tube. Cold drawn tube is relatively smooth, but generally has slight surface marks caused by drawing, heating, pickling, straightening and handling. There are five higher grades of finish listed in the Steel Products Manual (AISI) that are available on cold drawn tube to meet special applications. These are:

Class 1—Surface is free of all imperfections after removal of a definite maximum amount of O.D. stock to make it suitable for plating.

Class 2—Surface is free from all surface defects as shipped, except for light scores and pits.

Class 3—Surface has either cylinder or piston finish. Piston finish is free of longitudinal scores on outside; cylinder finish is free of longitudinal scores on inside.

Class 4—Outside surface is suitable for plating without previous polishing or buffing.

Class 5—Surfaces are polished and finish is superior to the other classes.

## Welded Steel Tubing

All welded tubing is produced from flat-rolled stock—either skelp, plate or strip—and is formed and welded by one of several methods. Furnace welding is the oldest. In this process the stock is heated in a furnace. For butt-welded tubing the stock, after reaching welding temperature, is drawn through either a welding die or welding rolls, shaped into tubular form and the edges brought together under pressure and welded. For lap-welded tubing the stock is shaped into tube with edges overlapping, reheated and then welded by pressing together the overlapping edges.

Newer methods involve cold forming of the flat steel through a series of rolls and then butt welding by either fusion or electric resistance welding. In electric resistance welding, electric current supplies the heat and the joint is completed by bringing together the two edges under pressure. In the fusion method atomic hydrogen, oxy-acetylene or arc welding is used to make the joint. No pressure is required. No filler metal is used, generally, except with arc welding. After welding the flash on the outside of the tube is removed; the flash on the inside may or may not be removed depending on the application of the tube.

Welded tubing can be further reduced, both in outside diameter and wall thickness by cold drawing methods similar to those used on seamless tube. This is done when other than standard sizes or shapes are required or when special mechanical properties are desired.

Welded tubing is manufactured from both cold rolled and hot rolled steel. Tubes of cold rolled steel, maintain closer limits on hardness and dimensions and are therefore most suitable for applications where close tolerances must me met, or where close control of temper or hardness is required. Also, there is a higher quality

## Carbon and Alloy Steel Tubing—Welded and Seamless

Typical Types and Properties

| AISI Steel Type | Seamless Tube: Hot Finished T.S., Psi. | Hot Finished Y.S., Psi. | Hot Finished % Elong. | Hot Finished BHN | Cold Finished (Finish Annealed) T.S., Psi. | Cold Finished Y.S., Psi. | Cold Finished % Elong. | Cold Finished BHN | Welded Tube: As-Welded T.S., Psi. | As-Welded Y.S., Psi. | As-Welded % Elong. | As-Welded BHN | Mandrel Cold Drawn (Unannealed) T.S., Psi. | Mandrel Cold Drawn Y.S., Psi. | Mandrel Cold Drawn % Elong. | Mandrel Cold Drawn BHN | Uses and Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1015** | 50,000 | 33,000 | 40 | 107 | 75,000 | 55,000 | 20 | 149 | 50,000 | 40,000 | 15-30 | 15-130 | 70,000 | 55,000 | 10 | 130-140 | Regular grade carried in stock. For general use |
| **1025** | 65,000 | 45,000 | 30 | 128 | 80,000 | 60,000 | 15 | 160 | 60,000 | 45,000 | 10-25 | 125-140 | 80,000 | 70,000 | 5 | 135-165 | Higher physicals than 1015 |
| **1030** | 70,000 | 46,000 | 25 | 135 | 83,000 | 65,000 | 12 | 173 | 65,000 | 50,000 | 10-20 | 135-165 | 85,000 | 75,000 | 10 | 165-200 | For variety of structural applications |
| **1035** | 72,000 | 47,000 | 25 | 143 | 85,000 | 70,000 | 15 | 170 | 70,000 | 48,000 | 20 | 185 | 88,000 | 78,000 | 5 | 170-190 | Rear axle housings, propeller shafts, working barrels. |
| **1040** | 75,000 | 50,000 | 25 | 149 | 90,000 | 75,000 | 13 | 180 | — | — | — | — | — | — | — | — | Automotive parts—truck and trailer axles |
| **1050** | 92,000 | 65,000 | 18 | 187 | 98,000 | 85,000 | 10 | 202 | — | — | — | — | — | — | — | — | Gives highest physical properties of regular carbon steels |
| **1118** | 60,000 | 40,000 | 30 | 116 | 75,000 | 60,000 | 15 | 149 | 60,000 | 40,000 | 30 | 116 | 80,000 | 70,000 | 10 | 159 | Free cutting steel; for screw machine products |
| **2317** | 70,000 | 55,000 | 30 | 137 | 95,000[1] | 85,000 | 10 | 192 | [2] | [2] | [2] | [2] | [2] | [2] | [2] | [2] | Carburizing grade |
| **2330** | 90,000 | 65,000 | 25 | 179 | 125,000[1] | 100,000 | 10 | 255 | [2] | [2] | [2] | [2] | [2] | [2] | [2] | [2] | Used where toughness in addition to strength is required |
| **2340** | 100,000 | 75,000 | 20 | 202 | 130,000[1] | 110,000 | 10 | 262 | — | — | — | — | — | — | — | — | Used where high strength is required |
| **3115** | 70,000 | 45,000 | 25 | 137 | 100,000[1] | 90,000 | 15 | 202 | [2] | [2] | [2] | [2] | [2] | [2] | [2] | [2] | Case hardening grade; high strength with heat treatment |
| **4130 and 8630** | 105,000 | 80,000 | 20 | 212 | 125,000 | 110,000 | 10 | 255 | 100,000 | 80,000 | 15-20 | 210 | 125,000 | 105,000 | 10 | 250-260 | For aircraft structural members |
| **4615** | 70,000 | 40,000 | 30 | 137 | 105,000[1] | 95,000 | 20 | 212 | 72,000 | 40,000 | 20-30 | 137 | 105,000 | 95,000 | 20 | 212 | Bearing races |
| **Low Alloy High Strength** | 67-75,000 | 50-60,000 | 20-35 | 78-85 | [2] | [2] | [2] | [2] | 67-75,000 | 55-60,000 | 20-35 | 78-85 | [2] | [2] | [2] | [2] | Gives high strength at low weight |
| **4140** | 130,000 | 90,000 | 15 | 262 | 140,000[1] | 120,000 | 10 | 285 | — | — | — | — | — | — | — | — | For parts requiring heat treatment to high physicals in heavy sections |

*The values given in this table are approximate and are compiled from several different sources.*

*The steel types listed are representative, but tubing is available in many other analyses.*

[1] *Hard drawn.* [2] *No figures available.*

*o make this oil burner shaft, a seamless steel tube is turned and ground to 17 separate ameters. It is threaded, tapped, chamfered and keywayed. The tolerances in some cases must e held to 0.0005 in. Although with tubing the cost of making this shaft is eight times that f the raw material, if bar stock were used the production cost would be considerably higher. Courtesy: Peter A. Frasse & Co., Inc. and Petroleum Heat & Power Co.)*

nish on tubing made of cold rolled steel, hich recommends it for uses where polishg, plating or organic finishing is necessary. n the other hand, organic finishes probly have better adhesion on the rougher t rolled steel surfaces. Cold rolled steel almost always used for the lighter gage be because of the lesser variation in ickness.

Welded steel tubing is available in pracally all the carbon steel grades up to 30 carbon and up to 0.35 carbon on speal order. Weldable alloy and stainless eel types are also available. The most mmonly used standard types are listed re with pertinent characteristics and operties.

In general, mechanical properties of elded tube in the as-welded condition are mparable to those of the flat stock analsis from which the tube is made. The rength properties of as-welded tube are, f course, somewhat lower, than cold drawn be, while the ductility is higher. Temper n be varied or further cold work performd on the tube to meet specific mechanical operty requirements just as in the case f seamless tube. Also, the mechanical properties can be increased by cold working the flat stock before forming into tube. This is done, for example, on tube stock for automobile propeller shafts.

Welded tubing can be formed and fabricated similar to seamless tubing by such methods as expanding, beading, flanging, bending and tapering. Fabricating properties, such as hot and cold workability, weldability and machinability, are again comparable to the flat stock analysis. The welded seam is capable of withstanding to an equal degree all the cold forming operations to which welded tube is normally subjected. In fact, in practically all respects welded tube is homogeneous and can be treated as if no weld were present.

Welded tube, not cold drawn, is available in a range of standard sizes from 1/4 in. to 5 in. and in wall thicknesses from 0.028 in. to 0.260 in. In general, the ratio of outside diameter to wall thickness should not be less than 10 to 1. Tolerances range from ±0.003 in. on smaller diameter tubes to proportionally greater tolerances on large diameters. These tolerances generally apply also to shapes other than round.

As mentioned previously the finish depends largely on whether the tube is made from hot or cold rolled stock. In either case, the inside and outside tube surfaces are smooth and free of scale. Higher grade finishes can, of course, be obtained on request.

As indicated, welded tube can be cold drawn, and is, for several reasons: (1) to provide tube having outside and inside diameters, and wall thicknesses other than standard; (2) to obtain closer dimensional tolerances; (3) to form cross sectional

## Stainless Steel Tubing—Welded and Seamless

**Typical Types and Properties (Annealed Condition)**

| | Mechanical Properties | | | | Fabricating Properties | | |
|---|---|---|---|---|---|---|---|
| Type | T.S., Psi. | Y.S., Psi. | % Elong. | BHN | Cold Forming | Machinability | Structure |
| 304 | 85,000 | 35,000 | 55 | 150 | Good | Fair but tough | Austenitic |
| 309S | 85,000 | 35,000 | 55 | 150 | Good | Fair but tough | Austenitic |
| 310 | 85,000 | 35,000 | 55 | 170 | Good | Fair but tough | Austenitic |
| 316 | 85,000 | 35,000 | 65 | 150 | Good | Fair but tough | Austenitic |
| 321 | 85,000 | 35,000 | 55 | 150 | Good | Fair but tough | Austenitic |
| 347 | 90,000 | 45,000 | 50 | 150 | Good | Fair but tough | Austenitic |
| 410 | 75,000 | 40,000 | 30 | 150 | Fair | Fair | Martensitic |
| 430 | 80,000 | 47,000 | 25 | 165 | Good | Fair | Ferritic |
| 446 | 85,000 | 53,000 | 25 | 165 | Poor | Fair | Ferritic |

*Values in this table are approximate.*

## Seamless Steel Tubing—Round Cold Finished

**Diameter and Wall Thickness Tolerances**

| | Permissible Variations from: | |
|---|---|---|
| Size O.D., In. | O.D., In. | I.D., In. |
| 3/16 to 1/2 Excl. (a) (b) | +0.004 | — |
| 1/2 to 1 1/2 Excl. (a) (b) (c) | +0.005 | −0.005 |
| 1 1/2 to 3 1/2 Excl. (a) (b) (c) | +0.010 | −0.010 |
| 3 1/2 to 5 1/2 Excl. (a) (b) (c) | +0.015 | −0.015 +0.005 |
| 5 1/2 to 8 Excl. (c) When Wall Is Less Than 5% of O.D. | ±0.030 | ±0.035 |
| 5 1/2 to 8 Excl. When Wall Is From 5% to 7.5% of O.D. | ±0.020 | ±0.025 |
| 5 1/2 to 8 Excl. (a) When Wall Is Over 7.5% of O.D. | +0.030 | −0.030 +0.015 |
| 8 to 10 3/4 Incl. (c) When Wall Is Less Than 5% of O.D. | ±0.045 | ±0.050 |
| 8 to 10 3/4 Incl. When Wall Is From 5% to 7.5% of O.D. | ±0.035 | ±0.040 |
| 8 to 10 3/4 Incl. (a) When Wall Is Over 7.5% of O.D. | +0.045 | −0.040 +0.015 |

*Except where otherwise specified, permissible wall thickness variation is ±10%.*

*(a) For tubes with I.D. less than 50% of O.D. or with wall more than 25% of O.D., or with wall over 1 1/4 in., or weighing more than 90 lb. per ft. which cannot be successfully drawn over a mandrel, the I.D. may vary over or under by an amount equal to 10% of the wall. The wall may vary 12 1/2% over or under that specified.*

*(b) For tubes with I.D. less than 1/2 in. (or less than 5/8 in. when the wall is more than 20% of the O.D.), which cannot be successfully drawn over a mandrel, the wall may vary 15% over or under that specified and the I.D. will be governed by the O.D. and wall variations.*

*(c) Tubing having a wall less than 3% of the O.D. cannot be straightened properly without a certain amount of distortion. Consequently, such tubes, while having an average O.D. and I.D. within the tolerances shown in the Table, will require an ovality tolerance of 1/2% over or under the nominal O.D. and I.D., this being in addition to the tolerances indicated in the table.*

**Welded Steel Tubing—Cold Rolled Carbon Steel**

Representative Tolerances

| Size of Tube | Wall Thickness B. W. Gage | Mandrel Swaged (Standard Tube) | | | Drawn Over Mandrel* | | |
|---|---|---|---|---|---|---|---|
| | | O.D., In. | I.D., In. | Oval, In. | O.D., In. | I.D., In. | Oval, In. |
| 1/4 to 3/8 | 16 to 22 | ±0.003 | ±0.008 | 0.003 | ±0.002 | ±0.005 | 0.003 |
| 1/4 to 3/8 | 14 | ±0.003 | ±0.010 | 0.003 | ±0.002 | ±0.007 | 0.003 |
| 1/2 to 5/8 | 20 to 22 | ±0.004 | ±0.005 | 0.004 | ±0.003 | ±0.003 | 0.003 |
| 1/2 to 5/8 | 16 to 18 | ±0.004 | ±0.005 | 0.004 | ±0.002 | ±0.002 | 0.003 |
| 1/2 to 5/8 | 12 to 14 | ±0.004 | ±0.009 | 0.004 | ±0.002 | ±0.005 | 0.003 |
| 3/4 to 1 1/8 | 18 to 22 | ±0.004 | ±0.005 | 0.005 | ±0.003 | ±0.003 | 0.004 |
| 3/4 to 1 1/8 | 14 to 16 | ±0.004 | ±0.005 | 0.005 | ±0.003 | ±0.003 | 0.004 |
| 3/4 to 1 1/8 | 11 to 13 | ±0.004 | ±0.008 | 0.005 | ±0.003 | ±0.003 | 0.004 |
| 1 1/4 to 2 | 18 to 22 | ±0.005 | ±0.006 | 0.008 | ±0.004 | ±0.004 | 0.005 |
| 1 1/4 to 2 | 14 to 16 | ±0.005 | ±0.006 | 0.006 | ±0.003 | ±0.003 | 0.005 |
| 1 1/4 to 2 | 9 to 13 | ±0.005 | ±0.008 | 0.006 | ±0.003 | ±0.003 | 0.004 |
| 2 1/8 to 2 1/2 | 18 to 20 | ±0.006 | ±0.007 | 0.010 | ±0.004 | ±0.004 | 0.005 |
| 2 1/8 to 2 1/2 | 14 to 16 | ±0.006 | ±0.007 | 0.008 | ±0.004 | ±0.004 | 0.005 |
| 2 1/8 to 2 1/2 | 9 to 13 | ±0.006 | ±0.009 | 0.008 | ±0.004 | ±0.004 | 0.004 |
| 2 5/8 to 3 | 18 to 20 | ±0.010 | ±0.012 | 0.020 | — | — | — |
| 2 5/8 to 3 | 14 to 16 | ±0.008 | ±0.010 | 0.015 | ±0.006 | ±0.006 | 0.008 |
| 2 5/8 to 3 | 9 to 13 | ±0.008 | ±0.010 | 0.012 | ±0.006 | ±0.006 | 0.008 |
| 3 1/8 to 3 1/2 | 16 to 18 | ±0.010 | ±0.012 | 0.016 | — | — | — |
| 3 1/8 to 3 1/2 | 9 to 14 | ±0.008 | ±0.012 | 0.014 | — | — | — |
| 3 5/8 to 4 | 14 to 16 | ±0.010 | ±0.014 | 0.018 | — | — | — |
| 3 5/8 to 4 | 8 to 13 | ±0.010 | ±0.016 | 0.014 | — | — | — |
| 4 1/8 to 5 | 14 to 16 | ±0.020 | ±0.020 | 0.025 | — | — | — |
| 4 1/8 to 5 | 8 to 13 | ±0.015 | ±0.018 | 0.020 | — | — | — |
| 5 1/8 to 5 1/2 | 10 to 16 | — | — | — | — | — | — |

*This table is not intended to be complete. For complete information, consult the producers.*
** O.D. up to 35% closer than standard.*
*I.D. up to 40% closer than standard.*

shapes other than round; and (4) to obtain special mechanical properties. Cold drawn welded tube generally has a somewhat better finish than tube in the as-welded condition. It also has higher strength and hardness, but lower elongation.

## Stainless Steel Tubing

Stainless steel tubing is manufactured in both welded and seamless forms by the conventional methods described earlier. In an accompanying table the most common types of stainless steel used for tubing are listed with their typical properties.

Seamless tubing can be furnished in either hot finished or cold finished form. The hot finished type is more difficult to process than plain carbon tubing and the finish is usually inferior. It is not suitable for polishing. All hot-finished tubing is supplied in the annealed condition with surfaces cleaned by pickling or shot blasting. The seamless cold finished type is furnished in the annealed condition with pickled surfaces. It is suitable for grinding or polishing within certain size limitations.

Welded stainless steel tubing is available in both mechanical and ornamental grades. The mechanical grades are in the annealed condition with pickled surfaces, and the ornamental grades are supplied in the as-welded (flash in) condition. The tubing can be ground or polished and can be obtained in sizes up to 4 in. O.D. with polished outside surface.

Stainless mechanical tubing is made in round, rectangular, or special shapes and is used for a wide range of mechanical or ornamental purposes.

## Aircraft Tubing

Although space does not permit detailed discussion of aircraft tubing, it deserves passing mention because it can often be used to advantage where special properties are required or where the tube will undergo special processing that will affect the surface.

Aircraft mechanical tubing is the term used to describe cold-drawn or hot-finished tube used in aircraft construction for parts requiring virtually complete removal of the outside surface, inside surface, or both. Because the surfaces will be destroyed or removed during fabrication the tubes are supplied with a relatively wide tolerance, both in size and surface finish. Otherwise it is no different from the regular mechanical tubing except that special analysis, physical properties, and aircraft quality steel is furnished when specified.

Aircraft (or Airframe) quality tubing refers to seamless cold drawn tube, or as-welded or welded and drawn tubing made of aircraft quality steel. It is produced to specified finish and dimensional tolerances for use in parts where machining or heat treatment of the tube is not required. However, in some instances this tubing can be formed, partially machined, ground or heat treated by the user. It can be supplied either normalized or stress relieved, annealed or heat-treated.

# Copper Alloy Tube

In the copper and brass industry tubular products are divided into four basic classes, and the class corresponding to mechanical tubing is commonly referred to as "commercial tube" rather than mechanical tubing. It should also be noted that in keeping with the industry's terminology the word "tube" is preferred to "tubing."

Practically all copper and brass tube is of the seamless type. There are about 16 different alloys generally available, ranging from soft copper to the harder, stronger, high-silicon bronze and Naval brass. The table lists the most commonly used alloys with their mechanical properties and fabricating characteristics.

Tubes such as copper and Muntz metal, which are readily hot worked, are produced as heavy walled tube by the Mannesman piercing process and then cold drawn to finished dimensions. Many of the other alloys are hot-extruded to form a tube with a heavy wall. Those more difficult to draw, such as cupro-nickel, are reduced in both

## Copper and Copper Alloy Tube

| Type | Nominal Composition, % | | | Mechanical Properties | | | | | | | | Fabrication Properties | | | Forms or Tempers Most Used | | | | Remarks and Typical Uses |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | T.S., Psi. | | Y.S., Psi. | | % Elong. in 2 In. | | Rockwell Hardness | | Cold Work (4) | Hot Work (4) | Machine Rating (5) | Drawn (1) | Hard Drawn (2) | Light Drawn (3) | Annealed | |
| | Cu | Zn | Others | Hard | Soft | Hard | Soft | Hard | Soft | Hard | Soft | | | | | | | | |
| Copper (Electrolytic Tough Pitch) | 99.92 | — | — | 55,000 | 32,000 | 50,000 | 10,000 | 8 | 45 | B60 | F40 | E | E | 20 | √ | √ | √ | √ | Radio parts, rotating bands, electrical parts |
| Deoxidized Copper | 99.94 | — | P 0.02 | 55,000 | 32,000 | 50,000 | 10,000 | 8 | 45 | B60 | F40 | E | E | 20 | √ | √ | √ | √ | Variety of uses; rotating bands, terminals for electrical appliances |
| Commercial Bronze | 90 | 10 | — | 60,000 | 38,000 | 53,000 | 12,000 | 6 | 50 | B69 | F57 | E | G | 20 | √ | √ | — | √ | Hardware, compacts, lipstick cases, rotating bands |
| Red Brass | 85 | 15 | — | 70,000 | 40,000 | 58,000 | 12,000 | 8 | 55 | B77 | F60 | E | G | 30 | √ | √ | √ | √ | Conduit, eyelets, fire extinguishers |
| Cartridge Brass | 70 | 30 | — | 78,000 | 47,000 | 64,000 | 15,000 | 8 | 65 | B82 | F64 | E | F | 30 | √ | √ | — | √ | Flashlight shells, lamp fixtures, socket shells, eyelets. For severe forming operations |
| Low Brass | 80 | 20 | — | 74,000 | 44,000 | 60,000 | 13,000 | 8 | 60 | B80 | F62 | E | F | 30 | √ | √ | — | √ | Bellows, pump liners |
| Phosphor Bronze | 95 | — | P 5 | 75,000 (½ hard) | — | 65,000 (½ hard) | — | — | 25 | B80 | — | E | P | 20 | — | √ | — | — | Lock washers, bushings, bellows |
| Muntz Metal | 60 | 40 | — | 74,000 | 56,000 | 55,000 | 23,000 | 10 | 50 | B80 | F82 | F | E | 40 | √ | √ | — | √ | For heavy walled and large dia. tubes for screw operations requiring much drilling |
| Low-Leaded Brass | 67 | 32.5 | — | 75,000 | 47,000 | 60,000 | 15,000 | 7 | 60 | B80 | F64 | E | P | 60 | √ | √ | — | √ | Machines freely, and withstands bending and flanging, and other moderate cold working |
| High-Leaded Brass | 67 | 31.4 | — | 75,000 | 52,000 | 60,000 | 20,000 | 7 | 50 | B80 | F75 | F | P | 80 | √ | √ | — | √ | General purpose screw machine products |
| Free Cutting Muntz Metal | 60.5 | 38.4 | Pb 1.1 | 80,000 | 54,000 | 60,000 | 20,000 | 6 | 40 | B85 | F80 | F | E | 70 | √ | √ | — | √ | Automatic screw machine products |
| Naval Brass | 60 | 39 | Sn 1.0 | 88,000 | — | 66,000 | — | 18 | — | B95 | — | F | E | 30 | √ | √ | — | — | Aircraft turnbuckle barrels |
| Aluminum Brass | 76 | 22 | Al 2 | — | 60,000 | — | 27,000 | — | 55 | — | F77 | E | F | 30 | — | — | — | √ | Ferrules |
| Cupro-Nickel | 70 | — | Ni 30 | — | 60,000 | — | 25,000 | — | 45 | — | F80 | G | G | 20 | — | — | — | √ | Ferrules |
| High-Silicon Bronze (A) | 94.8 | — | Si 3 | 93,000 | 57,000 | — | — | 22 | 70 | B92 | F78 | E | E | 30 | √ | √ | — | √ | Bushings, piston rings; good cold working properties such as bending and flaring |
| Low-Silicon Bronze (B) | 96.0 | — | Si 1.5 | 65,000 | 45,000 | 40,000 | 20,000 | 20 | 55 | B75 | F68 | E | E | 30 | √ | √ | — | √ | Electrical conduit; good cold working properties |
| Admiralty | 71 | 28 | Sn 1.0 | — | 53,000 | — | 22,000 | — | 65 | — | F75 | E | F | 30 | — | — | — | √ | Ferrules |

*(1) For general purpose where there is no real requirement for high strength or hardness on the one hand or for bending qualities on the other.*
*(2) Used only where there is a need for a tube as hard or as strong as is commercially feasible for the size in question.*
*(3) Used only where tube of some stiffness, yet capable of readily being bended or otherwise moderately cold work, is needed.*
*(4) E-Excellent, G-Good, F-Fair, P-Poor.*
*(5) Free Cutting Brass = 100.*

diameter and wall thickness by a rolling operation; and then drawn down to required size. Larger size tube is sometimes made by casting a heavy-walled shell and then reducing to size by a number of cold drawing operations.

Copper and brass commercial tube is commonly available in a wide range of sizes and shapes. While plain round tube is most widely used, all the shapes listed previously in the section on tubing shapes is available in copper and brass alloys. Preferred sizes of copper and copper-alloy round seamless tube normally run from about 1/8 to 12 in. O.D. and from 0.010 to 5/8 in. in wall thickness. The tolerances for this range of sizes are listed in the adjoining table.

Except where otherwise specified, tube is supplied with the drawn finish which is relatively smooth and has a bright appearance. In extruded tube the surface is slightly oxidized and has a dull appearance. Many other types of finishes can be obtained on special order.

Copper and copper alloy tube can be easily bent and shaped by the common cold and hot working methods. For machining applications free-cutting Muntz metal or high-lead brass is preferred for easy, fast cutting. Because of its smooth finish as drawn, copper and brass tube usually requires little finishing; where desirable it is readily plated.

Copper and copper alloy commercial tube has a wide variety of applications. Besides ornamental uses, it has many practical uses where corrosion is a factor, or where high electrical conductivity is required. The free machining compositions are used for a variety of screw machine products. Finally, its corrosion resistance combined with good ductility and strength have made it useful for a large range of miscellaneous items such as rotating bands, electrical fixtures, fire extinguishers, bellows, and even shoe lace eyelets.

## Copper and Copper Alloy Tube

### Mean Diameter Tolerances

*(All Tolerances Plus or Minus In.)*

| Specified Dia., In. | Tolerance Applies to | Tolerances, Nonrefractory Alloys | Tolerances, Refractory Alloys |
|---|---|---|---|
| Up to 1/8 Incl. | Inside dia. | 0.002 | 0.003 |
| Up to 1/8 Incl. | Outside dia. | 0.002 | 0.0025 |
| Over 1/8 to 5/8 Incl. | Inside or outside | 0.002 | 0.0025 |
| Over 5/8 to 1 Incl. | Inside or outside | 0.0025 | 0.003 |
| Over 1 to 2 Incl. | Inside or outside | 0.003 | 0.004 |
| Over 2 to 3 Incl. | Inside or outside | 0.004 | 0.005 |
| Over 3 to 4 Incl. | Inside or outside | 0.005 | 0.006 |
| Over 4 to 5 Incl. | Inside or outside | 0.006 | 0.008 |
| Over 5 to 6 Incl. | Inside or outside | 0.007 | 0.009 |
| Over 6 to 8 Incl. | Inside or outside | 0.008 | 0.010 |
| Over 8 to 10 Incl. | Inside or outside | 0.010 | 0.013 |

*The mean diameter of a tube is the average of the maximum and minimum outside diameters, or of the maximum and minimum inside diameters, as determined at any one cross-section of the tube.*

## Nickel and Nickel Alloy Tubing

### Typical Tolerances on Cold Drawn Seamless Tube (Round)

| Nominal Size, In. | Mean O.D., In. (See Notes 3 & 4) | Mean I.D., In. (See Notes 1, 3 & 4) | Wall Tolerances, % (See Note 1) |
|---|---|---|---|
| **Monel and "A" Nickel** | | | |
| Less than 1/2 I.D. | +0.005 −0.000 | See Note 2 | ±12½ |
| 1/2 I.D. to 1½ O.D., Incl. | ±0.005 | ±0.005 | ±10 |
| Over 1½ O.D. to 4½ O.D., Incl. | ±0.010 | ±0.010 | ±10 |
| Over 4½ O.D. to 6 O.D., Incl. | ±0.015 | ±0.015 | ±12½ |
| Over 6 O.D. to 7½ O.D., Incl. | ±0.020 | ±0.020 | ±12½ |
| Over 7½ O.D. to 8⅝ O.D., Incl. | ±0.025 | ±0.025 | ±12½ |
| **Inconel, "K" Monel and "Z" Nickel** | | | |
| Less than 1/2 I.D. | ±0.005 | See Note 2 | ±15 |
| 1/2 I.D. to 1½ O.D., Incl. | ±0.0075 | ±0.0075 | ±10 |
| Over 1½ O.D. to 3½ O.D., Incl. | ±0.010 | ±0.010 | ±10 |
| Over 3½ O.D. to 4½ O.D., Incl. | ±0.015 | ±0.015 | ±10 |
| Over 4½ O.D. to 6 O.D., Incl. | ±0.020 | ±0.020 | ±12½ |

**Notes**

Tolerances given above are applicable only to two dimensions at a time.

1. For all tubing in all tempers, with an I.D. less than 50% of the O.D., or with a wall more than 25% of the O.D., which cannot be successfully drawn over a mandrel, the I.D. may vary over or under by an amount equal to 10% of the wall, and the wall may vary 12½% over or under that specified.

2. For tubes in all tempers, with an I.D. less than 1/2 in. (or less than 5/8 in. when the wall is more than 20% of the O.D.), which cannot be successfully drawn over a mandrel, the I.D. will be governed by the O.D. and the wall variations.

3. Tubes in all tempers, having a wall less than 3% of the O.D., cannot be straightened properly without a certain amount of distortion. Consequently, such tubes, while having an average O.D. and I.D. within the permissible variations shown in the table, will have an ovality tolerance of 0.5% over and under the nominal O.D. and I.D., this being in addition to the tolerances indicated in the table.

4. Tubes furnished in the soft annealed temper are apt to possess more or less ovality or out-of-roundness due to warpage in soft annealing, or to subsequent straightening operations. Therefore, soft annealed tubes will not be as close to I.D. or O.D. as the table indicates.

# Nickel and Nickel Alloy Tubing

Nickel and nickel alloy mechanical tubing is produced in seamless and welded forms by much the same methods as those used in the manufacture of ferrous tubes. The principal compositions in which this tubing is commonly available are nickel, "Z" nickel, Monel, "K" Monel, and Inconel. Besides these, there are several others that serve as specialty tubing. These include "L" nickel, "220" nickel and "225" nickel, which are discussed in the section on specialty tubing.

Nickel and nickel alloy cold drawn tubing is available in a large range of sizes and in a variety of shapes. In round seamless tubing, outside diameters range from about ½ in. to 8⅝ in. and wall thicknesses from about 0.025 to 0.500 in. Specialty tubing, however, can be supplied in smaller sizes down to 0.010 in. O.D. and 0.0015 in. wall thickness. For sizes greater than 8⅝ in. O.D., extruded or welded tubing can be used. Extruded tubing can be furnished 2½ to 9¼ in. O.D. in heavy wall thicknesses (5/16 to ½ in. depending on O.D.). If desired the extruded tube can be cold drawn up to 8⅝ in. in dia., and in wall thicknesses up to I.P.S. dimensions.

Welded tubing is available in sizes from ⅛ to 22 in. O.D. Shorter lengths can be furnished up to 30 in. O.D. Wall thicknesses vary from 0.005 in. for small diameters, up to 0.187 in. for larger diameters. There are many uses for such tubes. Some of the applications include table rolls for paper making machines, sleeves for large diameter shafts, stems for large valves, and pump liners.

The tolerances attainable in nickel and nickel alloy tubing are in most respects quite similar to those of steel tubes. The table gives typical tolerances on cold drawn seamless tubes.

The outstanding characteristics of nickel and high-nickel alloys is its excellent corrosion resistance to a great variety of chemicals including practically all alkalis and the halogens. Therefore, since its cost is relatively high, nickel and nickel alloy tubing is selected mainly on the basis of its corrosion resistance. It also has wide use where elevated temperature or subzero temperatures are involved, and these properties combined with its corrosion resistance and high strength make it suitable for special service applications. For example, because of its freedom from scaling and intercrystalline attack, Inconel is used for thermocouple tubes, exhaust manifolds, heating elements for domestic electric ranges and submerged heaters, and for heat treating equipment and fixtures. Applications of other nickel alloys include: cupro-nickel for fishing rod ferrules and parts subjected to sea water corrosion, and ornamental applications; Monel for chemical equipment of all types, marine service where salt water is encountered, and surgical instruments; and nickel itself for

## Nickel and Nickel Alloy Seamless and Welded Tubing

Typical Properties

| Type | Mechanical Properties | | | | | | | | Fabrication Properties | | | Remarks and Uses |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ten. Str., Psi. | | Yield Str., Psi. | | % Elong. in 2 In. | | Rockwell Hardness | | Hot Working Range for Bending, F | | Relative Machinability[2] | |
| | Annealed | As-Drawn[1] | Annealed | As-Drawn[1] | Annealed | As-Drawn[1] | Annealed | As-Drawn[1] | Light | Heavy | | |
| "A" Nickel | 55-80,000 | 70-95,000 | 15-30,000 | 50-80,000 | 60-40 | 35-15 | B40-B65 | B80-B100 | 1,000-1,200 | 1,200-2,300 | 65[3] | For parts coming in contact with food, pharmaceuticals, etc.; for hospital equipment and electronics. |
| "Z" Nickel (Not Aged) | 90-120,000 | 110-150,000 | 30-60,000 | 60-130,000 | 50-25 | 35-15 | B74-B90 | B90-B100+ | 1,600-1,900 | 1,900-2,300 | 40[4] | Age-hardenable. Especially suited to large sections. |
| Monel | 70-85,000 | 85-125,000 | 25-45,000 | 60-120,000 | 50-35 | 30-10 | B60-B73 | B85-C24 | 1,200-1,700 | 1,700-2,150 | 65[5] | General purpose alloy. Used in marine equipment, hardware, food processing, chemical equipment. |
| "K" Monel (Not Aged) | 90-110,000 | 130-150,000 | 40-60,000 | 90-110,000 | 45-30 | 15-4 | B75-B90 | C18-C26 | 1,600-1,900 | 1,900-2,150 | 45[4] | Non-magnetic; age-hardenable. Bourdon tubing, torque tubes, pump bushings and sleeves, fishing rod parts, drill collars. |
| Inconel | 80-100,000 | 110-160,000 | 30-50,000 | 70-140,000 | 55-35 | 25-2 | B65-B85 | C8-C35 | 1,600-1,850 | 1,850-2,300 | 40[4] | Non-magnetic. Thermocouple tubes, food and dairy industry, heating devices and heat treating fixtures. |

*Tubes are also available in intermediate tempers. Nickel alloys other than those listed are also available on special order.*
[1] *Low-temperature, stress-equalized.* [2] *Based on bar stock using "R" Monel as the base (100); rated on tempers having best machinability.*
[3] *As drawn, stress equalized.* [4] *Annealed.* [5] *As-drawn, high-temperature, stress-relieved.*

a variety of chemical processing and electronic applications.

Nickel and nickel alloy tubing in the correct temper, can be readily worked by both hot and cold methods. In general nickel and its alloys can be hot worked similar to steel, providing proper attention is given to cleanliness, atmospheres and the use of low sulfur fuels. The hot malleability range varies with the degree of hot work and the alloy composition; the hot-working ranges are given for the common nickel tube materials in the table. These materials in the proper tempers can also be subjected to cold bending, coiling, expanding, rolling, upsetting, welding, slitting, etc. The high-nickel materials are not difficult to machine although different combinations of tooling, speeds, feeds and cutting compounds are required than those used with steels. In the table the nickel materials used in tubing are arbitrarily rated as to their machinability using "R" Monel, a machining grade of bar stock, as the base.

# Light Metal Tubing

## Aluminum

Tubing of aluminum and its alloys is produced either in the extruded or drawn form. All aluminum tubing goes through the extruded stage. It is produced from hollow tube blooms which are extruded from drilled, pierced of hollow "as-cast" ingots. Extruded tubing is manufactured to size in extrusion presses, and straightened by stretching or contour rolling. For smaller sizes and closer tolerances than possible in the extruded form, the tubing is further processed by cold drawing to final size. This processing also increases hardness and strength and is used to produce the cold worked tempers of non-heat-treatable alloy tubing.

While round sections are the most common form, seamless aluminum tubing is also produced in a variety of other shapes, including square, rectangular, oval, elliptical, hexagonal and octagonal.

Standard extruded tubing is generally limited in the outside greatest dimension to 1 in. and over, while wall thicknesses run from 0.050 to 1 in. Cold drawn tubing is produced in outside diameters from as small as 1/8 to as high as 8 in.; wall thicknesses generally vary from around 0.010 to 0.50 in., depending on the alloy, temper and size. The diameter and wall thickness tolerances that are possible in the standard range of sizes are given in the table.

Another table presented here lists the aluminum alloys commonly furnished in tube form. The alloys listed are available in a number of different tempers; only spread of properties obtainable over the range of tempers are given in the table.

Tubing for architectural purposes is usually of the 61S or R361 type in the T6 temper (solution heat treated and artificially aged). Perhaps the largest single use of aluminum tubing is for aircraft structural applications, for which 52S-O and 24S-T4 (solution heat treated) are most often used. For chemical and processing equipment 3S is largely used, although 2S is sometimes specified. While not strictly a mechanical application, aluminum mechanical tubing of the 63S-T6 type is being used extensively for portable irrigation systems; this tubing is extruded to size, and its light weight and good corrosion resistance make it especially adapted to this purpose.

The fabricating properties of aluminum and aluminum alloy tubing are, of course, similar to those of solid stock. As is well known, the alloys are less ductile than the pure metal; also there is a range of fabricating qualities among the tubing alloys in their different tempers, from 3S-O, which is slightly less ductile than 2S-O, to 75S-T6 which is used only where the amount of forming is limited to bending over rather liberal radii. All the alloys are readily machined and machinability ratings of the various alloys are given in the table.

### Aluminum Alloy Tubing
**Typical Alloys and Properties**

| Alloy Type | Extruded or Drawn | Mechanical Properties: T.S., Psi. | Y.S., Psi. | % Elong. | Hardness BHN (2) | Fabricating Properties (1): Cold Working | Machinability |
|---|---|---|---|---|---|---|---|
| 3S | E & D | 16-29,000 | 6-26,000 | 40-10 | 28-55 | A+ to C+ | B |
| 4S | D | 26-40,000 | 10-34,000 | 25-6 | 45-77 | — | — |
| 14S | E | 30-70,000 | 18-60,000 | 12-6 | 105-135 | C to C− | A |
| 17S or R317 | E & D | 26-62,000 | 10-40,000 | 22 | 45-105 | C | A |
| 24S | E & D | 30-73,000 | 15-57,000 | 22 | 47-130 | A to D+ | B to A |
| 52S | E & D | 27-41,000 | 12-36,000 | 30-8 | 45-85 | A+ to C+ | B |
| 53S | E | 16-39,000 | 7-33,000 | 35-13 | 26-80 | B to C+ | B |
| 61S or R361 | E & D | 22-40,000 | 14-35,000 | 16-10 | 30-95 | B | B |
| 63S | E | 22-35,000 | 13-30,000 | 20-12 | 42-73 | B | B |
| 75S | E | 33-82,000 | 15-72,000 | 16-11 | 60-150 | A to D | B to A |

*The values given in this table are approximate. Exact values depend upon the temper and dimensions of tube. (1) Fabricating properties are comparative with other aluminum alloys in this group. "A" is highest rating. (2) 500 kg., 10-mm. ball.*

### Aluminum Alloy Tubing
**Diameter and Wall Thickness Tolerances**
*(All Tolerances Plus or Minus In.)*

| Diameter, In. | Drawn Tube | Extruded Tube |
|---|---|---|
| **Diameter Tolerance** | | |
| 0.125-0.500 | 0.003 | — |
| 0.501-1.000 | 0.004 | 0.010 |
| 1.001-2.000 | 0.005 | 0.012 |
| 2.001-3.000 | 0.006 | — |
| 2.000-3.999 | — | 0.015 |
| 3.001-5.000 | 0.008 | — |
| 4.000-5.999 | — | 0.025 |
| 5.001-6.000 | 0.010 | — |
| 6.001-8.000 | 0.015 | 0.035 |
| 8.001-10.000 | 0.020 | 0.045 |
| 10.000-12.000 | 0.025 | 0.055 |
| 12.000-12.250 | — | 0.065 |
| **Wall Thickness** | **Wall Thickness Tolerance** | |
| up thru 0.062 | — | 0.007-0.010 |
| 0.010-0.035 | 0.002 | — |
| 0.036-0.049 | 0.003 | — |
| 0.050-0.120 | 0.004 | — |
| 0.063-0.124 | — | 0.008-0.015 |
| 0.121-0.203 | 0.005 | — |
| 0.125-0.249 | — | 0.009-0.020 |
| 0.204-0.300 | 0.008 | — |
| 0.250-0.374 | — | 0.011-0.025 |
| 0.301-0.375 | 0.012 | — |
| 0.375-0.499 | — | 0.015-0.035 |
| 0.376-0.500 | 0.032 | — |
| 0.500-0.749 | — | 0.020-0.045 |
| 0.750-0.999 | — | 0.035-0.055 |
| 1.000-1.499 | — | 0.045-0.065 |

*This table is not intended to be complete and gives only approximate values. It indicates the range of tolerances possible. For complete information on tolerances, consult the producers.*

## Magnesium Tubing
**Alloys and Typical Properties**

| Alloy Type | | Typical Mechanical Properties | | | | Form-ability (2) | Size Availability D/t Ratio (3) | | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | T.S., Psi. | Y.S., Psi. | % Elong. | Hardness BHN (1) | | Min. | Max. | |
| (4) | (5) | | | | | | | | |
| FS-1 | AM-C52S-F | 36,000 | 21,000 | 16 | 46 | A | 4 | 30 | Has best elongation and cold formability |
| J-1 | AM-C57S-F | 40,000 | 21,000 | 14 | 50 | B | 4 | 20 | General purpose alloy |
| M | AM-3S-F | 33,000 | 21,000 | 9 | 42 | A | 4 | 30 | Moderate strength alloy with best weldability, hot formability, and lowest cost |
| O-1 | AM-C58S-F | 44,000 | 24,000 | 12 | 54 | C | 4 | 15 | Highest strength tube. Heat treatable |
| — | AM-C58S-TS | 42,000 | 29,000 | 5 | 72 | D | — | — | Same as O-1; but heat treated |

*1) 500 kg. load, 10-mm. ball.*
*2) Based on magnesium alloys as a group. "A" is highest rating.*
*3) D/t = ratio of tube dia. to wall thickness.*
*4) Magnesium Div., Dow Chemical Co.*
*5) American Magnesium Corp.*

## agnesium

Magnesium tubing is produced by ex-rusion by two methods. In the rod mandrel ethod a bored billet is used. In the port-ole or supported-mandrel method, a solid illet is used. The solid billet is extruded hrough chambers in the male portion of he die, and the various segments are re-elded under pressure to form a tube.

Four magnesium alloys are available in be form. These are listed in the table long with their properties and charac-ristics. The mechanical properties vary ith the shape and size for the tube, there-re the properties listed are merely typical nd approximate. Also given are tables howing tolerances for round magnesium bing over the range of sizes available.

Magnesium tubing can be produced in a number of shapes and sizes. Any round, square, rectangular, hexagonal, or octagonal shaped tube of uniform wall thickness can be made by extrusion. Round tubing is most widely used and is at present the only standard item available. It is made in diameters from 0.25 to 12 in., and in a broad range of wall thicknesses. The maximum and minimum ratios of tubing diameter, to wall thickness regularly produced are given in the table of properties. In general, wall thicknesses range between 0.050 and 0.500 in.

Magnesium tubing can be formed in much the same way as other common metals, and the same type of equipment is used. Generally the forming operations are performed hot, particularly where bends of small radius are required. Magnesium is the easiest of the common metals to machine, and therefore the tube forms make very satisfactory screw machine stock.

Like aluminum alloys, magnesium tubing offers a combination of light weight with relatively high strength, and consequently is finding most use in applications where saving of weight is an important factor. One of the largest applications of magnesium tubing has been for rocket launcher tubes. Magnesium tubing has also been used to a considerable extent as an aircraft structural material. Other specific applications include hardware, conveyor rolls, furniture, and machinery and parts for the aircraft, textile and transportation industries.

## Magnesium Tubing
**Diameter and Ovality Tolerances—Round Tubing**

| Diameter, In. | Diameter Tolerance —Plus or Minus, In. | Ovality Tolerance —Plus or Minus, In. |
|---|---|---|
| Through 0.500 | 0.008 | 0.008 |
| 0.501-1.000 | 0.011 | 0.011 |
| 1.001-2.000 | 0.015 | 0.015 |
| 2.001-3.000 | 0.018 | 0.018 |
| 3.001-4.000 | 0.023 | 0.023 |
| 4.001-5.000 | 0.027 | 0.027 |
| 5.001-6.000 | 0.031 | 0.031 |
| 6.001-7.000 | 0.037 | 0.037 |

*The tolerances may be expressed as all plus or all minus, in which case double the tolerance given in the table will be used. Unless otherwise indicated, magnesium round tubing will be supplied to the plus or minus tolerance.*

*Ovality: The ovality or "out of roundness" tolerance is the difference in two diameters measured at right angles to each other.*

## Magnesium Tubing
**Wall Thickness Tolerances—Round Tubing**

| Wall Thickness, In. | Tolerance (Plus or Minus) for Various O.D., In. | | | | |
|---|---|---|---|---|---|
| | Up to ¾ In. Inclusive | Over ¾ In. to 1¼ In. | Over 1¼ In. to 3 In. | Over 3 In. to 5 In. | Over 5 In. to 7 In. |
| To 0.049 | 0.007 | 0.008 | 0.009 | — | — |
| 0.050-0.120 | 0.007 | 0.010 | 0.012 | 0.015 | — |
| 0.121-0.203 | 0.008 | 0.012 | 0.015 | 0.018 | 0.025 |
| 0.204-0.300 | — | 0.014 | 0.020 | 0.025 | 0.031 |
| 0.301-0.375 | — | 0.016 | 0.025 | 0.035 | 0.045 |
| 0.376-0.500 | — | 0.018 | 0.035 | 0.047 | 0.055 |

# Specialty Tubing

By specialty tubing we refer primarily to tubing produced for one specific purpose as distinct from regular mechancial tubing which is more generally applicable in industry. In some cases specialty tubing is made of materials previously discussed, but differs from regular tubing in its dimensional characteristics. In other cases, materials other than those already described are used to meet special service requirements.

In general any material, in addition to the common metals and alloys already discussed, which can be satisfactorily cold worked can be manufactured as specialty tubing. A few of the more common ones are discussed briefly below:

*Beryllium copper*—Although high in cost this alloy finds a variety of applications where its high strength, high electrical conductivity in the hardened condition, excellent fatigue strength, low drift factor, and good spring qualities can be used to advantage. It can be produced in both welded and seamless tube forms. Some typical applications are contact rolls for business machines, fishing poles, and Bourdon springs.

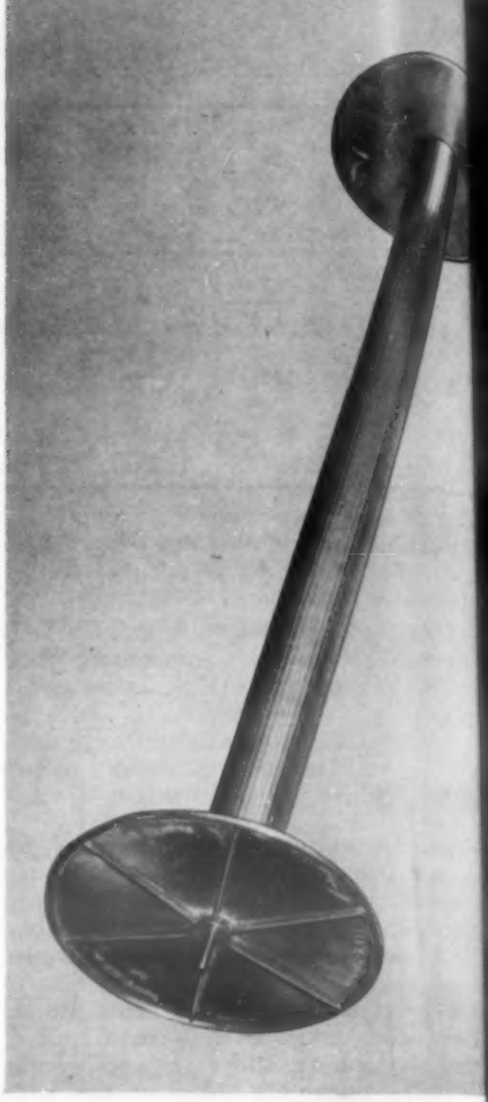
*Nickel alloys*—Much tubing for electronic products is made of nickel and several special nickel alloys. For example, two 99% nickel compositions, known as "220" and "225" nickel are used for hot cathodes. Another composition known as "L" nickel suitable for high temperature applications. In applications where sealing to glass is a requirement 36% nickel-iron, 42% nickel-iron, or 52% nickel-iron can be used. These alloy tubes find use in such things as testing and measuring devices, special electrical instrument applications, such as thermometry and phonograph pick-up arms.

*Other metals*—In addition to those mentioned above, specialty tubing can be obtained in many other metals and alloys. Some of these are nickel silver, Armco iron, "Z" nickel, Nichrome, Advance Alloy (Constantan), and many special ferrous types.

Very fine small tubing is also available for special applications. Seamless tubing can be produced in a number of alloys down to 0.012-in. O.D. and 0.0015-in. wall thickness. Welded tubing can be produced to similar fine dimensions but cannot be supplied in as wide a range of wall sizes as seamless. Perhaps the most outstanding application of this fine tubing is for hypodermic needles. Stainless steel and nickel alloys are frequently used.

Thin walled tubing is another specialty which has many applications including instrument springs, flexible metal hose, antennae, and a variety of mechanical parts. Wall thicknesses down to approximately 1% of the O.D. are possible. The range of light-wall tubing produced by one manufacturer runs from 1/16-in. O.D. by 0.0015-in. wall up to 4-in. O.D. by 0.049-in. wall.

Composite tubing is another specialty product which has some mechanical applications, but most of its uses are in the pressure tube and piping field. Composite tubing consists of two or more concentric tubes of different metals bonded together. The bond is a strong mechanical bond which permits the common forming operations to be performed on it without failure. The combinations, arrangements and thicknesses of the layers in composite tubing are practically unlimited.



***Light metal tubing is popular in the textil[e] industry. One outstanding application is th[e] use of aluminum for barrels of loom beam[s] which were formerly made of wood. A simila[r] use, for textile roving spools, is illustrate[d] here. The spool is made of fluted magnesium tubing fitted with die cast flanges at bo[th] ends, held on by a spring running throug[h] the length of the tubing. Weight is reduce[d] 25% over wood. They also have excelle[nt] balance, do not crack, warp or splinter, an[d] are less costly. (Courtesy: Dow Chemical Co.)***

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International Nickel Co.
Jones & Laughlin Steel Corp.
Magnesium Assn.
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Murray Tube Works
National Tube Co.
Peterson Steels, Inc.
Pittsburgh Steel Co.
Republic Steel Corp., Steel & Tubes Div.
Revere Copper & Brass, Inc.
Reynolds Metals Co.
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Seamless Steel Tube Institute
Standard Tube Co.
Steel & Tubes Div., Republic Steel Corp.
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MATERIALS & METHODS Engineering File Facts

NUMBER 170
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MATERIALS: Heat Resisting Alloys

# Attack on Four Heat Resisting Alloys by Various Compounds After 17 Hr. Heating in Air at 1500 F

| Compound | Purity | Fusibility at 1500 F[1] | Attack After 17 Hr. in Air at 1500 F[2] | | | |
|---|---|---|---|---|---|---|
| | | | S-816 | S-590 | Hastelloy B | Haynes Stellite No. 21 |
| Aluminum Oxide | 99%[3] | 3 | N | N | N | N |
| Aluminum Phosphate | Tech. | 2 | M | S | H | N |
| Arsenous Oxide | Tech. | 1 | N | N | N | N |
| Barium Carbonate | Tech. | 2 | N | N | H | S |
| Barium Chloride | C.P. | 2 | S | S | M | M |
| Barium Hydroxide | C.P. | 1 | S | S | S | S |
| Barium Nitrate | C.P. | 1 | N | N | N | N |
| Barium Sulfate | C.P. | 3 | S | S | M | M |
| Beryllium Oxide | C.P. | 3 | N | N | N | N |
| Bismuth Trioxide | C.P. | 1 | M | M | S | M |
| Bone Ash | Com. | 3 | N | N | N | N |
| Borax | Tech. | 1 | N | N | H | S |
| Boric Acid | C.P. | 1 | S | S | M | S |
| Cadmium Acetate | C.P. | 1 | N | N | M | — |
| Cadmium Sulfide | C.P. | 1 | N | N | M | N |
| Cadmium Tungstate | C.P. | 1 | N | N | H | H |
| Calcium Carbonate | C.P. | 3 | S | N | H | N |
| Calcium Chloride | C.P. | 1 | M | S | S | H |
| Calcium Sulfate | C.P. | 3 | N | N | N | N |
| Chalcopyrite | Com. | 3 | H | M | H | S |
| Chromic Oxide | C.P. | 3 | N | N | M | S |
| Cobalt Oxide | C.P. | 2 | N | N | H | N |
| Cryolite | Com. | 1 | S | S | H | M |
| Cupric Oxide | C.P. | 1 | N | N | S | N |
| Derry Spar | Com. | 3 | N | N | N | N |
| Ferric Oxide | C.P. | 3 | S | S | N | S |
| Fluorspar | Com. | 2 | S | N | M | N |
| Lanthanum Nitrate | C.P. | 1 | N | N | N | N |
| Lanthanum Oxide | C.P. | 3 | N | N | N | N |
| Lead Bromide | C.P. | 2 | S | M | N | S |
| Lead Carbonate (White Lead) | C.P. | 2 | M | S | M | M |
| Lead Chromate | C.P. | 1 | N | N | H | N |
| Lead Oxide (Red Lead) | C.P. | 2 | M | M | H | H |
| Litharge | Tech. | 2 | M | M | H | S |
| Lithium Carbonate | U.S.P. | 1 | M | M | M | S |
| Magnesium Carbonate | Tech. | 3 | N | N | N | N |
| Magnesium Oxide | Tech. | 3 | N | N | H | N |
| Magnesium Sulfate | C.P. | 1 | N | N | N | N |
| Manganese Dioxide | C.P. | 3 | N | N | N | N |
| Molybdenum Trioxide | C.P. | 1 | N | S | N | N |
| Nepheline Seyenite | Com. | 3 | N | N | N | S |
| Nickel Oxide | C.P. | 3 | N | N | M | N |
| Oxford Crystal Spar | Com. | 3 | N | N | N | N |
| Potassium Alum | C.P. | 1 | N | N | H | N |
| Potassium Carbonate | A.C.S. | 1 | M | M | H | S |
| Potassium Dichromate | Reagent | 1 | N | N | S | N |
| Silicon Dioxide | Com. | 3 | N | N | N | N |
| Sodium Aluminate | Reagent | 1 | M | H | H | M |
| Sodium Antimonate | C.P. | 3 | N | N | S | S |
| Sodium Carbonate | Tech. | 1 | N | M | H | S |
| Sodium Pyrophosphate | C.P. | 1 | M | S | H | S |
| Sodium Tungstate | C.P. | 1 | N | N | H | S |
| Strontium Carbonate | C.P. | 3 | N | N | H | N |
| Strontium Sulfate | C.P. | 1 | N | N | M | N |
| Thorium Oxide | C.P. | 3 | N | N | N | N |
| Tin Oxide | C.P. | 3 | N | N | N | N |
| Titanium Dioxide | C.P. | 3 | S | N | S | S |
| Wollastonite | Com. | 3 | N | N | N | N |
| Zinc Oxide | Tech. | 3 | N | N | N | N |
| Zinc Phosphate | C.P. | 3 | N | N | S | — |
| Zirconium Dioxide | C.P. | 3 | N | N | N | N |

[1] *Numbers refer to degree of fusibility. Number 1 indicates compound has melted or sublimed during test; 2 refers to a sintering action only; and 3 indicates that neither melting nor sintering occurred at the test temperature. Fusing with oxide scale may in some cases have caused greater fusibility than might otherwise be expected from reported melting points.*

[2] *Letter symbols refer to degree of attack. N refers to no visible attack; S, to a slight attack as evidenced by discoloration or staining; M, to moderate attack as distinguished by somewhat more scale formation than normal with some shallow pitting; and H, to heavy attack as evidenced by excessive scale formation accompanied by deep pitting and etching of alloy surface.*

[3] *Aluminum Ore Co. number A-1. Contains 0.6% sodium oxide ($Na_2O$).*

*(Continued on page 107)*

## Composition, Source and Form of Four Alloys

| Alloy | Source | Form[1] | Chemical Composition, %[2] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cr | Ni | Co | Mo | W | Cb | Fe | C | Mn | Si |
| S-816 | Allegheny Ludlum Steel Corp. | 0.050-in. sheet | 20.26 | 19.90 | 43.45 | 4.16 | 4.65 | 3.63 | 2.58 | 0.30 | 0.50 | 0.45 |
| S-590 | Allegheny Ludlum Steel Corp. | 0.050-in. sheet | 19.15 | 19.13 | 19.63 | 3.95 | 4.10 | 4.19 | 27.93[3] | 0.47 | 0.69 | 0.76 |
| Hastelloy B | Haynes Stellite Co. | ⅛-in. slabs cut from turbine blades | — | 65.1 | — | 28.6 | — | — | 4.7 | 0.05 | 0.59 | 0.19 |
| Haynes Stellite No. 21 | Haynes Stellite Co. | 0.050-in. sheet | 25.0 | — | 69.0 | 6.0 | — | — | — | 0.24 | — | — |

[1] *The S-816 and S-590 materials were hot rolled at 2150 to 2200 F, annealed 25 min. at 2180 F, air cooled, sandblasted, scrubbed, cold rolled on pass, buckled, and sheared. Hastelloy B was cut from surplus cast turbine blades. Information regarding preparation and treatment of Haynes Stellite No. 21 sheet was not available.*

[2] *Compositions of S-816 and S-590 are for heats supplied by manufacturer. Compositions of Hastelloy B and Haynes Stellite No. 21 are not for actual heats used but are typical of these alloys. Analysis in each case was supplied by the manufacturer.*

[3] *By difference.*

## Attack of 16 Compounds on Hastelloy B in Air, Carbon Dioxide and Helium Atmospheres After 17 Hr. Heating at 1500 F

| Compound[1] | Atmosphere[2] | | |
|---|---|---|---|
| | Air | Carbon Dioxide | Helium |
| Barium Carbonate | H | M | S |
| Borax | H | N | N |
| Calcium Carbonate | H | M | N |
| Cobalt Oxide | H | S | N |
| Cryolite | H | N | N |
| Fluorspar | M | N | N |
| Lead Chromate | H | N | N |
| Lead Oxide (Red Lead) | H | M | M |
| Lepidolite | H | N | N |
| Litharge | H | M | M |
| Magnesium Oxide | H | N | N |
| Potassium Alum | H | N | N |
| Potassium Carbonate | H | N | N |
| Sodium Aluminate | H | S | N |
| Sodium Carbonate | H | N | N |
| Sodium Tungstate | H | N | N |

[1] *See table on preceding page for composition and purity.*

[2] *Attack designations same as in table on preceding page—that is, H, heavy; M, moderate; S, slight; and N, none.*

*Based on data furnished by the National Advisory Committee for Aeronautics*

# MATERIALS & METHODS

# DIGEST

A selective condensation of articles — presenting new developments and ideas in materials and their processing — from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

## German Views on Temper Brittleness and Embrittlement of Steel

Temper brittleness appears to have been a problem to the Germans during the war, as shown by a comprehensive investigation presented at that time on the effect of carbon, manganese, phosphorus and chromium. The report by W. Bischof and L. Böttger, which has just been published in Vol. 19 (1948) of *Archiv für das Eisenhüttenwesen* (German), covers not only temper brittleness but also the embrittlement caused by holding 100 to 1000 hr. at 930 F.

Tests were made on 153 experimental heats with 0.01 to 0.61 carbon, 0.04 to 3.2 manganese, 0.012 to 0.159 phosphorus and up to 11.9% chromium. Additional data, some on production heats, were given in the discussion. Unlike much recent French and American work, embrittlement was measured in terms of room temperature impact values rather than by a complete temperature-impact curve.

Chromium up to 12% had no effect on either type of embrittlement, provided the carbon, manganese and phosphorus contents were low. When any of these three elements was increased, embrittlement was found in the chromium steels. This embrittlement increased rapidly with the chromium content over about 1 to 1.5% to reach a maximum at about 3 to 5% chromium, after which it gradually decreased. Manganese over a certain minimum content—about 1 to 1.5%—caused even low carbon and phosphorus steels to be susceptible to embrittlement.

Increasing carbon up to about 0.3% produced increased embrittlement in both chromium and manganese steels. The effect diminished with higher carbon contents. High phosphorus had a deleterious effect on the susceptibility of chromium steels to embrittlement, even when the carbon and manganese were low.

The rate of embrittlement of the chromium steels was increased by phosphorus, manganese and carbon, with phosphorus having the most pronounced and carbon the weakest effect. There was a certain recovery of the impact properties of the chromium steels with higher phosphorus and carbon after longer holding at 930 F. This type of recovery was found in the manganese steels only with the higher carbon contents.

The authors concluded that the existing theories on temper brittleness were inadequate, to say the least. Several of the discussers took a less pessimistic view.

## Developments in Metals as Reported in American Society for Metals Papers

While space does not permit a digest of all the excellent papers presented before the annual meeting of the *American Society for Metals,* held in Philadelphia in October, a few which seem to be of particular interest to materials engineers are reviewed here.

### High Temperature Alloys

Materials for high and low temperature service received wide attention in the technical sessions, for the development of suitable materials to withstand the extremes of temperature is still a formidable problem.

N. J. Grant and J. R. Lane reported on their interesting study of the aging characteristics of four cast high-temperature alloys. The paper, "Aging in Gas Turbine Type Alloys," showed that although the alloys differed widely in composition, they behaved quite similarly in their aging characteristics. The alloys investigated were low-carbon Vitallium, the alloy known as 6059, and a modification of Multimet N-155. It was also found that the added strength resulting from aging was important only if the metal did not already contain a nearly continuous carbide network.

A long range program to study the stability of steels at high temperatures has been undertaken by A. B. Wilder and J. O. Light. The program will run over a period of 11 years and cover more than 100 different steels. Their paper, "Stability of Steels at Elevated Temperatures," is a progress report; it reports on the examination of 20 of the steels in regard to their impact properties, oxidation characteristics, and structural changes after 10,000 hr. of exposure at 900 to 1200 F.

In another paper, "Short-Time High-Temperature Deformation Characteristics of Several Sheet Alloys," by J. Miller and G. Guarnieri, the true stress-true strain characteristics of several alloys over a range of temperatures and strain rates were determined. The alloys were SAE 1020 steel, the reference material, Inconel and Inconel X, and S-816. From the data, information about the properties of the alloys during high-temperature deformation can be obtained.

There continues to be a need for high rupture strength materials at elevated temperatures, and a project to develop a nickel-base alloy having superior rupture strength at 1500 F was covered in the paper, "Nickel-Base Alloys for High Temperature Applications," by A. G. Guy. The nickel alloys contained 3 to 9 aluminum, 0 to 15 molybdenum, 4 to 20 chromium and smaller additions of boron, columbium, iron, silicon, and manganese. A number of the alloys showed a higher rupture strength than the present cobalt-base alloys; they also had excellent oxidation resistance and moderate fatigue strength, but lower elongation and impact resistance.

While the 16-25-6 (chromium-nickel-molybdenum) alloy has excellent high temperature strength properties, it has the unfortunate characteristic of rapid oxidation in an oxidizing atmosphere of restricted circulation. W. C. Leslie and M. G. Fontana investigated this problem and have some answers in their paper, "Mechanism of the Rapid Oxidation of High-Temperature, High-Strength Alloys Containing Molybdenum." Among other things, they indicated that it may be possible to decrease the rate of oxidation by decreasing carbon content to a minimum; also, by decreasing

# DIGEST

nitrogen and molybdenum contents and in-creasing the chromium content.

### Alloys for Low Temperature Service

As in the high temperature field, the search continues for better materials for low temperature service. G. R. Brophy and A. J. Miller, in their paper, "The Metallography and Heat Treatment of 8 to 10% Nickel Steel," report on a nickel steel developed for use at temperatures as low as —320 F. The alloy has the following composition: 0.12 max. carbon, 0.35 to 1.00 manganese, 0.15 to 0.30 silicon, and 8 to 10% nickel. To develop its optimum properties, it must be given a special heat treatment, which is described in detail in the paper.

In another paper results of low temperature tests on a group of commercial wrought aircraft materials were presented. The paper, "Mechanical Properties of Aircraft Alloys at Very Low Temperatures," was given by J. L. Zambrow and M. G. Fontana. The materials, including aluminum alloys, nickel steels, stainless steels, aluminum bronze, and AZ31X magnesium alloy, were subjected to Charpy impact tests down to –424 F, and fatigue hardness and tensile tests down to about –320 F.

### Nonferrous Alloys

In the nonferrous session an interesting paper, "Effect of Alloying Elements on Recrystallization, Electrical Conductivity and Rupture of Aluminum," was presented by R. H. Harrington. He investigated 11 different dilute binary aluminum alloys and, among other things, found that binary alloys containing iron, magnesium or zirconium have the best combinations of strength and electrical conductivity. The alloys with zirconium and iron had the highest rupture strengths in the annealed condition; in the cold worked condition, the alloy containing magnesium was better than the zirconium alloy.

R. I. Jaffee, E. I. Beidler and R. H. Ramsey reported on processing nonferrous corrugated diaphragms in the paper, "Forming and Heat Treatment of Corrugated Diaphragms." Sheets, 0.0005 in. thick, of beryllium copper, copper-nickel-manganese (60-20-20), Ni-Span C, and Grade A phosphor bronze, were tested. In forming the diaphragms there is local stretching equivalent to 5 to 10% reduction in thickness at the tops, and somewhat smaller contractions at the bottoms of the corrugations. It was found that this deformation increased the strengths of the age hardenable alloys after subsequent aging; also, that the alloys can be heat treated in accordance with the age hardening curve of the original stock without decreasing the mechanical properties of the most deformed sections by overaging.

# DIGEST

### Testing Methods

A number of noteworthy papers on new testing developments were presented. R. D. Haworth, Jr., in his paper, "The Abrasion Resistance of Metals," described a new abrasion testing machine to determine quantitatively the resistance of metals to either dry or wet abrasion. The method involves establishing values for loss in weight due to abrasion. The author used this method to study the abrasion resistance of many different metals, and reports on the results.

A unique vacuum device for use in gas analysis of carbon steels, certain alloy steels, nonferrous materials, and powders was described in a paper, "A Versatile Vacuum-Fusion Apparatus," by M. W. Mallett. By this method the gas sample is removed from the extraction apparatus by an automatic Toepler pump and is analyzed in a modified Orsat apparatus. The accuracy of the method on carbon steels is 0.001% for both oxygen and nitrogen.

A new method for comparing the flow of soft solders on sheet metals was described in a paper, "Solder Flow Tester for Tin Plate," by J. J. Sperotto. The method is simple and rapid, and is particularly adapted to thin sheets such as tinplate. A constant-volume pellet of solder is placed on a tinplate disk, together with an excess of flux, and heated above the melting point of the solder. The amount of spreading out of the solder is measured with a planimeter. The method is designed so as to prevent distortion of the sample plate, and is also provided with a means of introducing an inert gas to reduce oxidation of the plate or solder.

G. DeVries, in his paper on "An End Quenched Bar for Deep Hardening Steels," explained an end-quench test that measures the hardenability of deep hardening steels. While the specimen is similar to the Jominy bar, it is 6 in. long instead of 4 in. During end-quenching, the top 2 in. of the bar is held at a temperature of around 1200 F to retard cooling all along the bar. After an hour in the fixture the bar is removed and immersion-quenched in water. Hardnesses are then taken the same way as in the Jominy test.

● An interesting development made by the *Arthur Balfour & Co., Ltd.*, of Sheffield, England, is a cutter for boring solid drill collar forgings, such as are used in oil drilling. These collars are up to 40 ft. long, and the rate of penetration of this cutter is reported to be ten times faster than that of any other tool previously used for the job. The cutter is screwed, by an internal square thread, to a 25-ft. hollow

boring bar; the collar is bored half-way through and then turned end-for-end and the bore completed. The cutter has a cylindrical body, the end of which is slightly coned and provided with a radial blade of "Balfalloy" hard metal. This blade projects slightly beyond the periphery of the body, so that it cuts on a diameter slightly greater than the body diameter, and its end cutting edge has a length of about half the radius of the body.

## The Adhesion of Tin-Base Bearing Alloys

The adhesion of a bearing alloy to the backing material greatly affects its behavior in service. The properties of the bond depend in part on its metallurgical character, as shown by the work of P. G. Forrester and L. T. Greenfield, *Journal of the Institute of Metals* (British) July 1948, on the effect of the composition of the bearing alloy and the backing material. The bearing alloys were tin base with about 7 antimony and 3.5 or 7% copper.

The adhesion to properly tinned mild steel was unaffected by residual nickel and chromium in the steel or by carbon contents up to 0.4%. The 7% copper alloy, cast statically, gave a brittle bond due to the precipitation of a copper-tin constituent ($Cu_6Sn_5$). In centrifugal casting of the lower copper alloy, the copper content of the lining was increased to 7 to 11%, with a high concentration of the copper-tin constituent near the bond but no brittle layer. The fact that a high copper lining with adequate bond strength can be obtained by centrifugal casting is of considerable practical signficance, for the fatigue strength of tin-base alloys increases with the copper content.

With cast iron, the use of ordinary pickles leads to unsatisfactory tinning and very poor adhesion. When the cast iron was given a prior treatment in a fused salt bath, moderately good adhesion of the bearing alloy was obtained. Tin bronzes, with or without phosphorus and zinc, gave a bond strength (under static loads) about the same as that with steel. There was some tendency towards brittleness because of the copper-tin constituent at the bond. The thickness of this layer and the consequent brittleness could be reduced by decreasing the times and temperatures of tinning and lining. Obviously, difficulties are likely to arise with large shells, which cannot be tinned as rapidly as smaller ones and which must be cooled more slowly. The bond, with suitably prepared aluminum, was almost as strong as that obtained on steel

# DIGEST

or bronze and showed no brittleness. The satisfactory methods of preparation were scratch-brushing while the aluminum was immersed in the molten tin, and the use of certain chloride fluxes.

## Low Temperature Performance of 18:8 Stainless Steel

The increasing use of metals at sub-zero temperatures has called for more investigation of the low temperature behavior of metals. In a report by D. J. McAdam, G. W. Geil and F. J. Cromwell, appearing in the *Journal of Research*, May 1948, the low temperature performance of 18:8 stainless steels is covered.

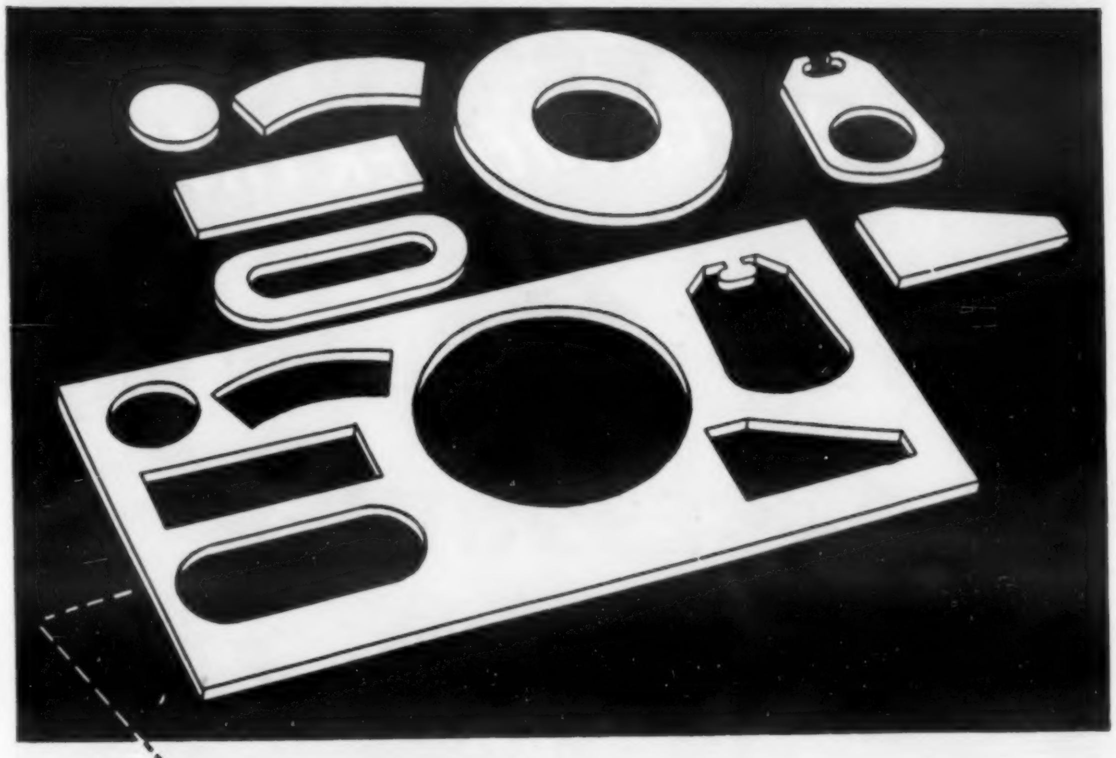
Various alloys of this group, including ferritic and metastable austenitic types, were tested by means of tension tests of notched and unnotched specimens between room temperature and –370 F. It was found that while the strength of most metals can be evaluated by use of yield stress, ultimate stress and fracture stress, for 18:8 stainless steels at low temperatures, three additional indices are required.

Study of the ferritic type alloy showed that the effect of low temperatures on the ductility is evidently similar to the effect on the ductility of annealed low-carbon steels. For use at low temperatures, ductility would possibly be improved if some austenite were retained along with the ferrite and the precipitated constituent. In investigating the influence of notches in the mechanical properties of 18:8 alloys, it was found that although ductility decreased with decrease in notch angle and with decrease in temperature, the combined influence of these two variables on the ductility was less for the 18:8 alloys than for pearlitic steels.

## Successful Heat Treating of High Quality Pressure Die Castings

The heat treatment of aluminum alloy die castings is generally considered to be commercially impossible because the castings blister and distort during the solution treatment. J. L. Erickson, who has been working on this problem since 1939, summarizes his conclusions in *Metallurgia* (British), Aug. 1948.

The blistering is caused by the trapped air porosity in the die casting. The origin of the air obviously is the air which is in the die cavity, the runner cavity and the





# DIGEST

injection well at the time of casting. It may be augmented by the gaseous products formed by the breakdown of die lubricants.

There is no completely foolproof method for producing die castings free of trapped air porosity. The evacuation of the die by a vacuum pump is expensive and cumbersome but warrants further investigation. The most universal method is venting of the die cavity; its main limitation is that further escape of the trapped air is prevented once the vents are sealed by solidifying metal. The author's work has shown that the use of small overflows is ineffectual, but that the amount of trapped air is minimized by proper venting and large overflows.

The manner in which the molten metal enters the die cavity has a great bearing on whether the confined air within the die cavity will be forced out through the vents, washed into the overflows, or trapped. When molten metal is forced into a die cavity through large gates at slow injection rates, blistering is reduced even without the aid of vents or overflows. When vents and overflows are added, the blistering disappears.

The author states that, with the aid of these principles, he produces commercial die castings which have superior mechanical properties as-cast and which may be heated to elevated temperatures without blistering or distortion.

## Sintered Iron-Carbon Materials

Although sintered parts of iron and carbon have found many commercial uses, there has been relatively little fundamental work on the effect of production variables on their properties. H. Wiemer and W. A. Fischer in Vol. 19 (1948) of the *Archiv für das Eisenhuttenwesen* (German) have studied the influence of sintering time, temperature and atmosphere, as well as the type of iron powder and carbon addition.

In vacuum sintering, it was possible to obtain ferritic-graphitic, ferritic-graphitic-pearlitic or pearlitic structures. Changes in the types of graphite and iron powders affected the sintering temperature at which each structure was obtained. When the raw materials and sintering conditions were constant, these structures were reproducible. The tensile strength varied from 1400 to 85,300 psi., depending on the amount and type of the carbon addition, and the sintering time and temperature.

The atmosphere during sintering had no noticeable effect on the mechanical properties of the sintered parts. Hydrogen caused a greater carbon loss than nitrogen or vacuum, while carbon monoxide was

# DIGEST

satisfactory if the specimen was heated rapidly through the lower temperature ranges. Under their conditions, sintering in solid carbonaceous media resulted in an increase in carbon of about 0.8%; this absorbed carbon diffused uniformly throughout the specimens.

The inter-relationship of hardness, tensile strength and carbon content (0.3 to 1.0%) was determined for samples compacted under 42.5 to 57 tons per sq. in. and sintered for 2 to 8 hr. at 2190 and 2370 F. There was a linear relationship between hardness and strength. For each compacting pressure, there was also a linear relationship between the final carbon content and the hardness, with the higher pressures giving higher hardness for a specific carbon content. There was more scatter in the relationship between tensile strength and elongation, but the higher pressures tended to give higher elongations for a given strength.

A few tests were made on heat treated sintered samples. Although tensile strengths over 142,000 psi. could be obtained, the specimens were very brittle. It appears to be impossible to heat treat sintered parts to give better ductility than as-sintered parts at the same tensile strength.

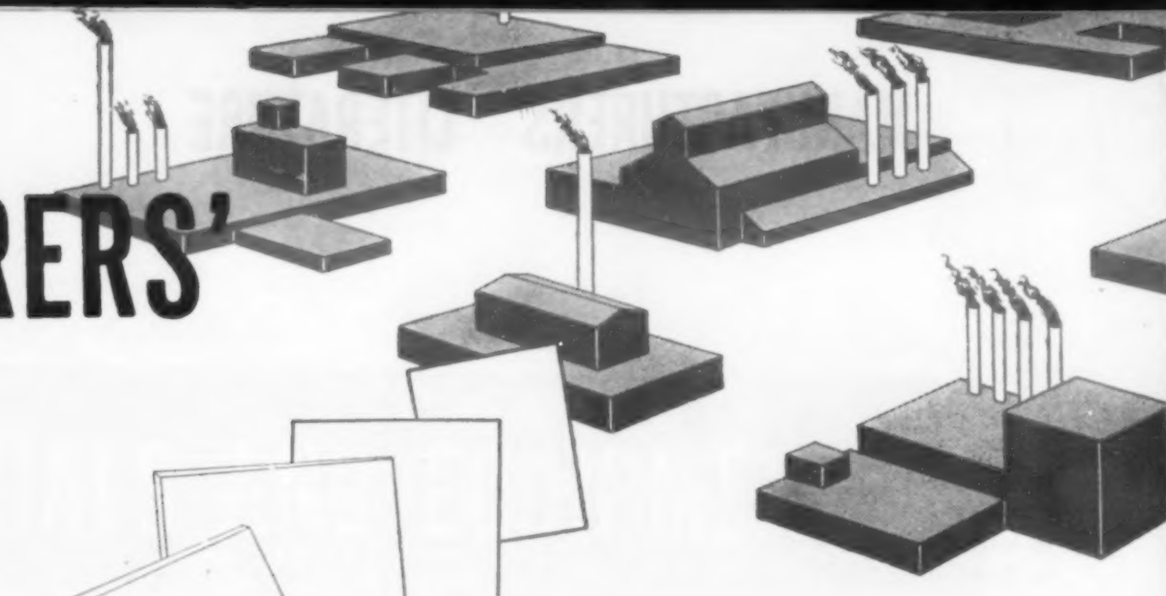
## A New Light-Metal and Plastic Laminate

A new promising non-metallic for the designer is an aluminum-plastic laminate recently developed in Great Britain by Bakelite, Ltd. and marketed by Warerite, Ltd. As described in the Sept. 1948 issue of *Light Metals* (British), the laminate has a phenolic veneer on both sides of a core of either pure aluminum or an aluminum alloy.

The use of the aluminum core makes it possible to form the sheet readily. There is less tendency to revert to the original flat sheet than is found with ordinary paper laminate. Even under conditions of varying humidity, there is no tendency to buckle or bow. Another important advantage of this new material is that it can meet the requirements of the non-inflammable classification of materials. It withstands flame better than sheets bonded with phenolic resin and filled with glass fiber or asbestos fabric. As a matter of fact, it is the first decorative plastic material to be graded as non-inflammable.

The plastic veneer can be black or any standard dark color, wood grain or pattern. Handsome and unusual decorative effects may be achieved by machining away parts of the plastic to reveal the bright metallic core.

# MANUFACTURERS' LITERATURE



## Materials

### Iron and Steel

**Stainless Clad Flat Rolled Steel.** Complete data on Permaclad, a stainless clad flat rolled steel available in sheets and plates, are presented by the Alan Wood Steel Co. in this 8-page, illustrated folder. (1)

**Tool Steel Selector and Identification Chart.** The Carpenter Steel Co. has just issued a helpful reference wall chart of Carpenter matched tool and die steels for quickly and easily selecting and identifying the right steel for each job. (2)

**Gray Iron Specifications.** A 4-page summary of 14 separate sets of gray iron specifications covering automotive, high pressure, high temperature, alloy, railroad, pipe, pipe fittings and general castings has just been released by the Gray Iron Founders' Society, Inc. (3)

**Tool Steels.** The McInnes Steel Co. has just issued a revised chart of comparable tool steel grades, covering high-speed steels, hot work steel, special alloy steel, alloy tool steels and carbon tool steels. (4)

**Tool Steels.** The A. Milne & Co. is offering two helpful charts relating to tool steels—one a chart of comparable tool steel grades, the other a detailed tool steel selector, giving complete data on nondeforming, water hardening, shock resistant, hot work and high-speed tool steels. (5)

**Carbon and Stainless Steel Tubing.** Complete data on seamless and welded carbon steel tubing, stainless tubing and pipe, structural tubing, and seamless and welded boiler tubes are presented by Joseph T. Ryerson & Son, Inc. in a new 32-page bulletin. (6)

### Nonferrous Metals

**Bearing Bronze.** The use of Non-Gran bronze, an alloy having a nongranular structure, in nonferrous and centrifugal castings, stock bars, precision machined parts, etc., is discussed in this 4-page, illustrated bulletin released by the American Non-Gran Bronze Co. (7)

**Nickel-Chromium Alloy Products.** A varied group of products of the electric furnace cast of Illium G, a corrosion resistant nickel-chromium alloy, is described and illustrated in this 4-page bulletin, No. 105, offered by the Burgess-Parr Co. (8)

**Titanium Metal.** The physical, tensile, chemical and comparative properties of ductile 99.5%+ pure titanium metal, available in sponge or ingot form, are tabulated in a 13-page folder published by the Pigments Dept. of E. I. du Pont de Nemours & Co. (Inc.). (9)

**Special Molds for Casting.** The third of a series of new application bulletins, No. 30, describes and illustrates in eight pages the use of Meehanite molds for casting soil pipe centrifugally. Meehanite Metal Corp. (10)

**Metal Powders.** Six types of metal powders, and their typical applications in the fields of powder metallurgy, electronics, chemistry, welding rods, etc., are covered in this single sheet issued by Plastics Metals, a division of the National Radiator Co. (11)

### Parts and Forms

**Aluminum Impact Extrusions.** The principles of the Alcoa impact extrusion process for producing aluminum impact extrusions, and their commercial applications, are interestingly presented by the Aluminum Co. of America in this 44-page, illustrated booklet, No. AD-124. (12)

**Forgings.** The many advantages of using the forgings produced by the American Forge Div. of the American Brake Shoe Co. are listed in this 4-page, illustrated bulletin, as well as several scenes of the facilities of the Forge Div. (13)

**Welding Branch Pipe Outlets.** Three types of WeldOlets—butt welding, threaded, and socket welding branch pipe outlets—are described and illustrated, and complete installation instructions, sizes, dimensions, weights, prices, temperature pressure ratings and material specifications are given in this 24-page catalog, No. W-2, published by the Forged Fittings Div. of the Bonney Forge & Tool Works. (14)

**Sintered Carbide Tips, Tools, Etc.** Specifications and prices of a complete line of Firthite sintered tungsten carbide tips and tools, boring bits, Mechanigript adjustable tool holders, and special tips, nibs and wear parts made to customers' specifications are featured in this 28-page, illustrated catalog, No. FE-127, offered by the Firth Sterling Steel & Carbide Corp. (15)

**Aluminum Extrusions.** This 2-page, illustrated bulletin discusses extruded aluminum rods, bars, tubing, hollow sections, structural members and special shapes produced by the Harvey Aluminum Div. of Harvey Machine Co., Inc. (16)

**Nickel Alloy Steel Castings.** The use of nickel alloy steel castings in a variety of industries, typical applications, recommended compositions, and specification values are all included in this attractive, 32-page, illustrated catalog issued by the International Nickel Co., Inc. (17)

**Alloy Castings.** Compositions of various heat resistant and corrosion resistant alloy castings, their properties and applications are all included in this 16-page, illustrated bulletin, No. 111, just issued by the Michiana Products Corp. (18)

**Nonferrous Powder Parts.** This interesting, 8-page bulletin describes and illustrates typical applications and properties of nonferrous powder parts, and includes several specific cost case histories—distributed by the New Jersey Zinc Co. (19)

**Plaster Mold Castings.** The Ohio Precision Castings, Inc. offers a single-page, illustrated bulletin explaining the advantages of the plaster mold technique in producing high-lead bronze castings for Shartle knuckle joints. (20)

**Precision Shapes.** The many advantages of using precision shapes produced by Precision Shapes, Inc., which are fabricated by a patented continuous milling process

# MANUFACTURERS' LITERATURE

from solid stock or from rolled, drawn or extruded shapes of any material, and milled in long bars to close tolerances, are featured in this 4-page, illustrated bulletin. (21)

**Carbon and Stainless Steel Tubing.** Complete data on seamless and welded carbon steel tubing, stainless tubing and pipe, structural tubing, and seamless and welded boiler tubes are presented by Joseph T. Ryerson & Son, Inc. in a new 32-page bulletin. (22)

**Cast Iron Pulleys.** Specifications and prices of a complete line of Blue Face cast iron pulleys made in diameters and face widths to meet most any commercial requirement are included in this 16-page, illustrated bulletin, No. P-848, offered by the Sprout, Waldron & Co. (23)

**Forgings.** The huge facilities of the Willys-Overland Forge Div. of Willys-Overland Motors, Inc. for producing 80 million lb. of quality forgings a year are profusely illustrated and described in a 28-page catalog. (24)

## Plastics

**Laminated Plastic.** The many applications of Formica, a laminated plastic product made with synthetic resins of the phenolic, urea or melamine types and cured into a hard compact material by heat and pressure, are described and illustrated in an 8-page folder, No. lb-12, issued by Formica Insulation Co. (25)

**Silicone Resins, Oils, Greases, Etc.** Typical applications, charts and tables are included in this 30-page, illustrated bulletin, No. CDR-57, covering the new silicone resins, oils, greases, water repellents and rubber produced by the Resin & Insulation Materials Div. of the General Electric Co. (26)

**Flame-Resistant Cellulose Acetates.** Production methods, physical properties and original design ideas of several types of flame-resistant cellulose acetates are presented by the Cellulose Products Dept. of the Hercules Powder Co. in an 8-page, illustrated reprint. (27)

**Plastic Pipes and Fittings.** The chemical resistance and physical properties of Mills-Plastic pipes and fittings, produced by the Elmer E. Mills Corp. for a wide variety of chemical and industrial uses, are featured in this 4-page, illustrated bulletin. (28)

**Fiberglas-Reinforced Plastics.** The properties, applications, economics and typical manufacturing methods of Fiberglas-reinforced plastics, which greatly increase the range of sizes, strengths, shapes and properties of products that can be molded and pressed from modern resins, are presented by the Owens-Corning Fiberglas Corp. in a 36-page, illustrated catalog. (29)

**Thermosetting Plastic.** This 4-page, illustrated bulletin issued by the Plaskon Div. of the Libbey-Owens-Ford Glass Co. contains interesting data on Plaskon Alkyd molding compound, a new thermosetting plastic material with excellent electrical characteristics, unique molding properties, high heat resistance, low moisture absorption, and superior dimensional stability. A table of physical properties is included. (30)

## Nonmetallics

**Alloying Ingredient for Rubber, Wax and Resin.** The Enjay Co., Inc. has just published a 45-page manual covering the processing and compounding of Vistanex (polyisobutylene), a compounding or alloying ingredient to improve various qualities of rubbers, waxes and resins. (31)

# Methods and Equipment

## Heat Treating

**Surface Hardening Machines.** Specific examples of the use of the Flamatic hardening machine, with high temperature flames and electronic control of the workpiece temperature, by various companies, and its many advantages, are featured in this 16-page, illustrated booklet, No. M-1658, issued by the Flamatic Div. of the Cincinnati Milling Machine Co. (32)

**Heat Treating Furnaces.** A variety of electric and fuel-fired furnaces and controlled atmosphere generating assemblies for bright annealing, brazing, hardening, sintering and soldering operations are described and illustrated in this 4-page bulletin, released by Sargeant & Wilbur, Inc. (33)

## Welding and Joining

**Stitching Machines.** A complete line of Acme-Morrison metal stitchers for stitching metal to metal or to plastic, rubber, asbestos, wood, felt, etc., thus eliminating the use of rivets, screws, nails or spot welding, is described and illustrated in this 8-page bulletin, offered by the Stitching Wire Div. of the Acme Steel Co. Specifications are included. (34)

**Solders.** Bulletin No. 201, four pages, covers a variety of Alpha tri-core solders, including rosin-filled solder, "leak-pruf" acid-filled solder, solid wire solder, and preforms—produced by Alpha Metals, Inc. Tables of physical characteristics and a detailed solder selection guide are included. (35)

**Fluxing Stick.** This 4-page, pocket-size folder discusses the new Amco No. 323 fluxing stick, the only 100% active flux in stick form that can be used on all metals except aluminum. American Solder & Flux Co. (36)

**Balanced Welding Positioner.** The many advantageous features of the Model A200 universal balanced welding positioner, produced by the Aronson Machine Co., are described and illustrated in this 4-page bulletin. Specifications and prices are included. (37)

**Welding Branch Pipe Outlets.** Three types of WeldOlets—butt welding, threaded, and socket welding branch pipe outlets—are described and illustrated, and complete installation instructions, sizes, dimensions, weights, prices, temperature pressure ratings and material specifications are given in this 24-page catalog, No. W-2, published by the Forged Fittings Div. of the Bonney Forge & Tool Works. (38)

**Blind Rivets.** Both the self-plugging and pull-through types of Cherry blind rivets for use in a variety of applications are described and illustrated in this 4-page bulletin, No. 4K-2, offered by the Cherry Rivet Co. (39)

**Automatic Flash and Butt Welders.** Both the Model DBW-5 flash welder for the automatic welding of saw blades, tubes, rods, etc., and the Model DBW-1 butt welder for joining all saw bands up to ⅝-in. width are described and illustrated in the 2-page bulletin, No. 48-502, issued by the DoAll Co. Detailed specifications are included. (40)

**Automatic Arc Welder.** Complete data on the features and construction of an automatic arc welder produced by Elge Associates are presented in this illustrated, single sheet. (41)

**Blind Rivets.** Detailed specifications of a complete line of Rivnuts—accurately machined, internally threaded blind rivets which also serve as blind nut plates after installation—are included in this 28-page, illustrated

# New MATERIALS AND EQUIPMENT

## New Testing Machines and Aids

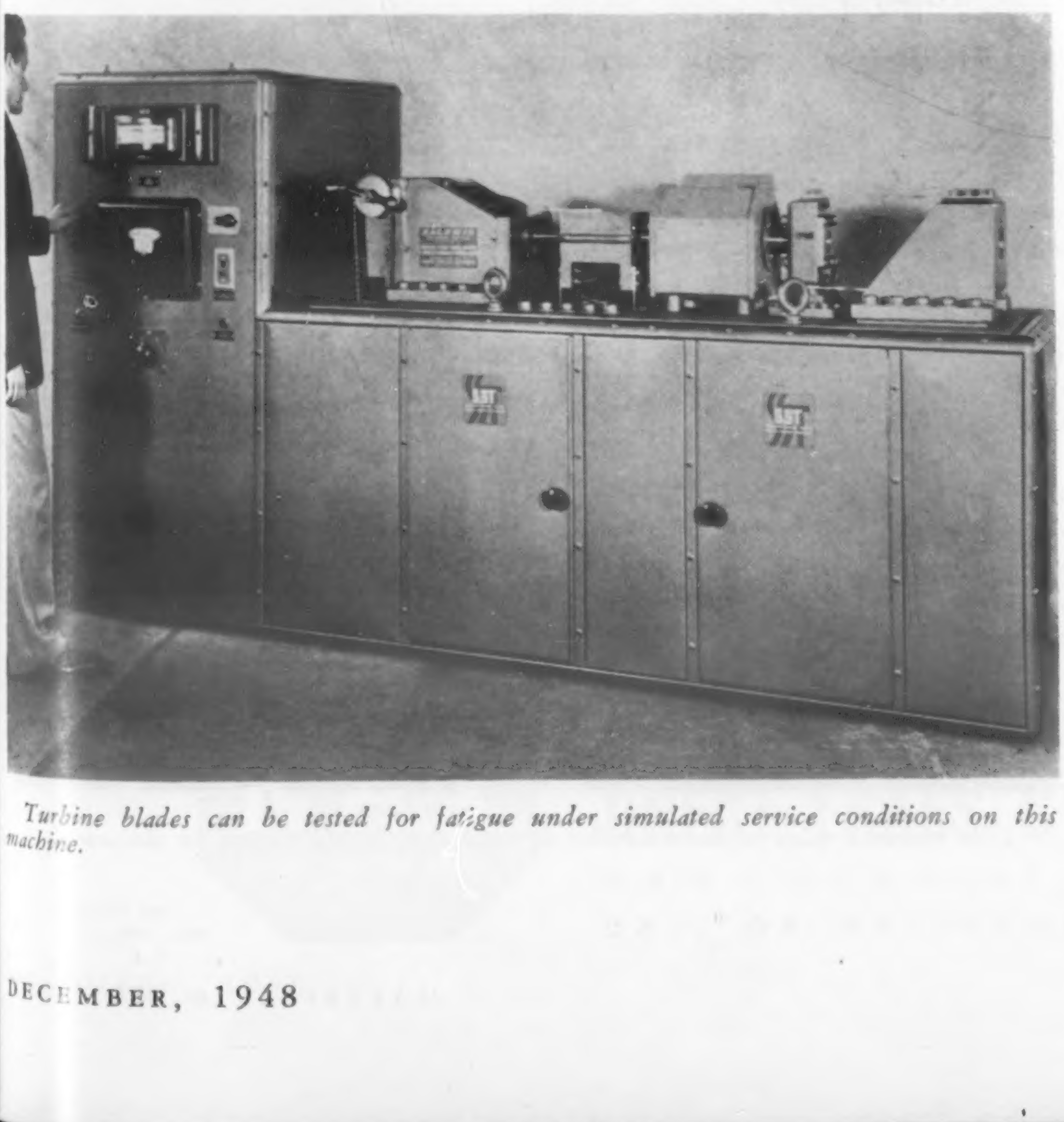
### Turbine Blade Fatigue Tester

A new fatigue testing machine, designed to subject turbine blades and materials to fatigue loads under conditions similar to those in high temperature turbine service, has been developed by the *Baldwin Locomotive Works,* Philadelphia 42. This machine applies alternating flexure loads up to ±1350 lb. to a specimen at a frequency of 3600 cycles per min. while it is held at temperatures up to 1800 F and is under tensile loads up to 8000 lb. The machine is reported to be the first to enable fatigue tests to combine the two types of loading on specimens. Test specimens in the furnace are held on each side by grips in a fixed head and an oscillating head.

In the operation of the machine, known as the Sonntag SF-5, flexure loads are applied by the centrifugal force of a mass rotating at constant speed in an oscillating frame. This force is accurately controlled by varying the distance between the mass and its center of rotation. Inertia forces of this mass are compensated by carefully designed springs and calibrating weights.

Automatic controls maintain a constant tension on the specimen; stop the main motor if the specimen breaks, if creep is greater than 1/8 in., and if the amplitude of the oscillator exceeds the setting and endangers flex plate guides; and they maintain furnace temperature and rate of power input.

Tensile loads, applied by a motor that drives the sprocket, are controlled by means of a sensitive relay and a switch in a proving ring that indicates the tensile load. The SF-5 machine is mounted on a frame that floats on seismic springs, thus preventing transmission of vibrations to the floor.



*Turbine blades can be tested for fatigue under simulated service conditions on this machine.*

### Tensile Tester for Rubber

Rubber and other high-elongation materials can be tested in the new tensile machine announced by *Scott Testers, Inc.,* Providence, R. I. The head on this tester is of the inclination balance type with one adjustable resistance weight compensating for specimen thickness. This resistance weight is adjusted by means of a screw actuated by a handle located at the lower end of the pendulum lever.

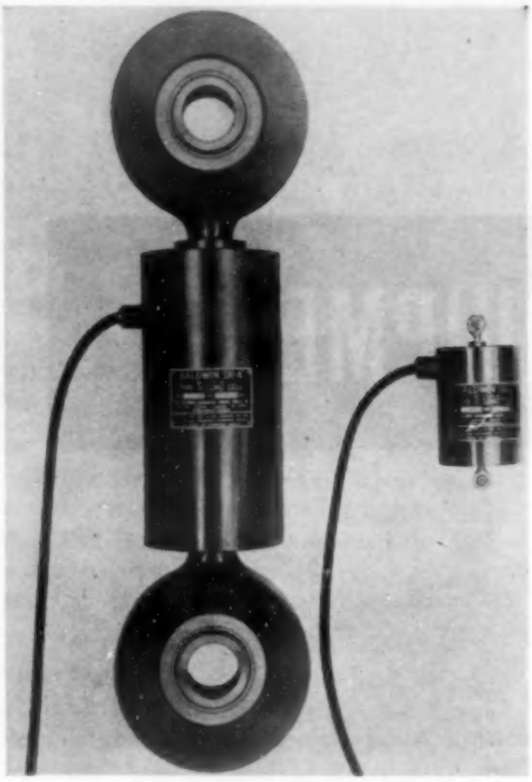
A second vernier adjustment is incorporated into the pendulum to compensate for the width of the specimen as cut by a standard die. This range on the 0.025-in. is ±0.005 in., thus eliminating this variable influence from the true tensile determinations.

Another feature of this instrument is an electrical solenoid for disengaging the pawls from the quadrant during the test. This is actuated by the tension of the sample. The release of this tension at the rupture of the sample engages the pawls, retaining the maximum tensile value. The return of the pendulum to the O position is accomplished manually. The source of electrical current for this feature is incorporated into the electrical recording equipment; no additional supply is necessary.

The use of an entirely different stylus driving mechanism has been incorporated into the recording of the test values. The glass covered spark stylus is attached to a rigid carriage bar. This bar moves through four polished center guides that rotate on ground pivot points. The purpose of this design is two-fold: (1) To reduce to a minimum the influence of the recording equipment upon the test results; and (2) to equally space the load recordings across the Tensilgram.

### Universal Load Cell

Both tension and compression loads can be measured by means of a new SR-4 load cell, Type U, announced by the *Baldwin Locomotive Works,* Philadelphia 42. The



*One type of tensile load fitting for the new load cell is shown here.*

pick-up elements are resistance wire strain gages which are bonded to a steel load-responsive member and hermetically sealed within a rugged cylinder. The dimensions of this member change slightly under load, increasing or decreasing the length of the wire of the gages and thus changing their electrical resistance. This change is calibrated in units of weight, which may be indicated by a pointer on a dial, or recorded on a chart, or used to actuate relays or control mechanisms.

Fittings for tension or compression loads are attached in female threaded connections in both ends of the cell. For compression loads a bearing button is screwed into the top and the base may rest on a load-carrying surface or may be attached to other suitable supports.

Applications include load weighing and the general field of testing, particularly the testing of structures such as aircraft. The new cell can also be used when loads reverse between tension and compression. It is also applicable to instrumentation for the control of industrial processes.

Four load capacities are available: 500, 2,000, 10,000, and 50,000 lb.

#### Strain Rate Pacer

Operating in conjunction with Baldwin testing machines, a new type strain rate pacer is announced by the *Baldwin Locomotive Works,* Philadelphia 42. The feature of this pacer is its more accurate and direct indication of the rate of displacement between test specimen gage points as compared with pacing the rate of motion of the testing machine crosshead.

There are two essential elements of the strain rate pacer indicator. One is a dotted disk, rotated by a synchronous motor at predetermined speeds of 0.5, 0.75, 1.0, 1.5, 2.0 and 2.5 rpm. by means of different gear combinations. The other is a coaxial pointer which is rotated by a self-synchronous motor that is under the control of a self-synchronous generator unit in the recorder, at a rate that is proportional to the strain in the specimen. The straining rate in the test specimen can be set and maintained by adjusting the testing machine load rate control valves until pointer speed coincides with predetermined disk spe[ed].

Pacing speeds are a combined functi[on] of strain-follower magnification and spe[ed] of rotation of the pacing disk. The strai[n] magnification selector in the recorder pe[r]mits interpreting a revolution of the poin[ter] in several values of strain.

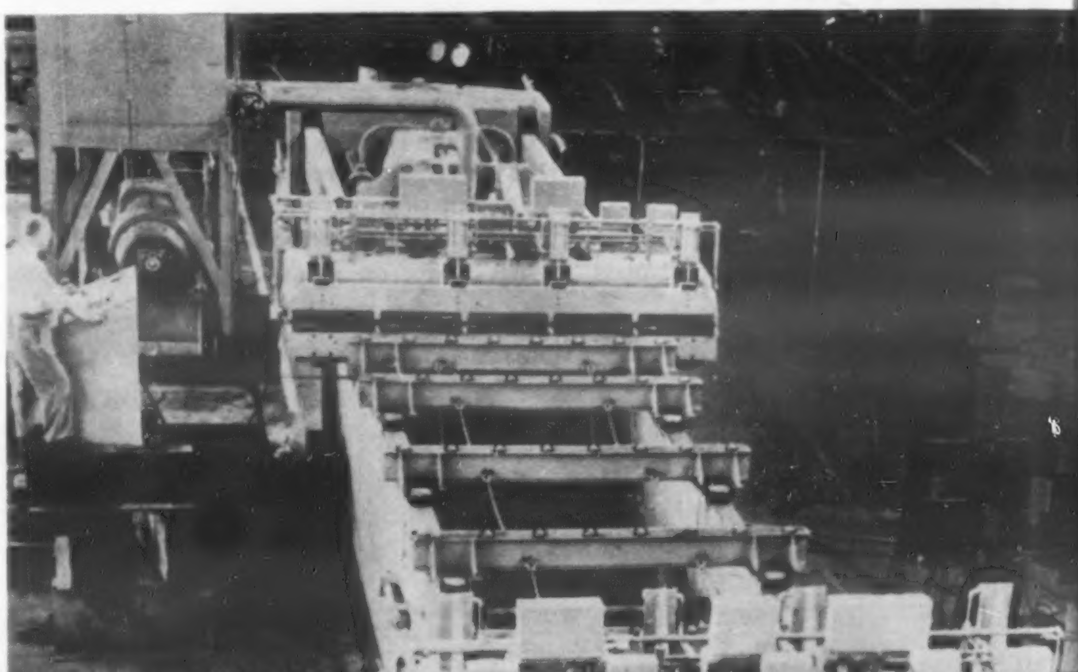
## Plate Stretcher-Leveller Has 1000-Ton Capacity

A stretcher-leveller of special design, believed to be the largest in the world, was recently installed in a steel plate mill. The machine, which was built by *Hydropress, Inc.,* 570 Lexington Ave., New York, is of the self-contained oil hydraulic type, has a capacity of 100 tons, and handles plate and sheet up to 11 ft. wide and 31 ft. long.

A bed of welded construction absorbs stretching forces so that the foundations have only to carry the dead weight of the machine. Two gripheads are provided. The main griphead is actuated by the hydraulic stretching cylinder, while the position of the other griphead is adjustable to compensate for the varying length of the plates. This adjustable head is movable along the stretcher bed by means of an electric motor and suitable drive. It is secured in oper[at]ing position by two heavy locking pi[ns] which are operated by air cylinders. Wed[ge] shaped shoes of special design in the thr[oats] of the gripheads insure a firm gripping [of] the plates to withstand stretching forces.

A straightening device in front of th[e] gripheads is provided to flatten a warp[ed] or bent plate end. The movement of th[e] straightening ledge is accomplished b[y] means of remote controlled air cylinde[rs].

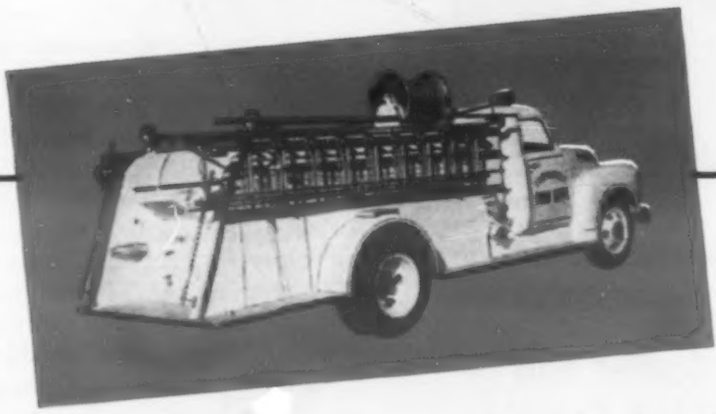
Pressure adjustment over a wide ran[ge] is provided for handling thinner and na[r]rower plates at the accurate required-pre[s]sure. The amount of stretching is shown [on] an instrument of the dial type which [is] automatically caused to indicate the stret[ch] when the actual stretching operation star[ts].



*This hydraulic plate stretcher-leveller is reputed to be the largest in the world.*

# "INCREASED EFFICIENCY...DECREASED COSTS WITH N-A-X HIGH-TENSILE STEEL"

**Fire Fighter Truck Company, Rock Island, Illinois**

Here is what the Fire Fighter Truck Company of Rock Island, Illinois has to say about N-A-X HIGH-TENSILE steel.

"In the use of this steel, we have increased the efficiency of our fire trucks and at the same time decreased our construction costs. We are now permitted to increase the hose carrying capacity using the same gauges as we formerly did with plain hot rolled sheet steel.

"The added strength of N-A-X HIGH-TENSILE permits us to install booster tanks of larger gallonage. The corrosion-resistant properties of the steel has shown to good advantage in that longer life is noted in our booster tank.

"We have found that in applying paint to this steel we can secure a better and longer lasting bond due to its impact- and abrasion-resistant qualities. These same qualities reduce shop imperfections from abrasion and impact, thus reducing surface refinishing prior to painting."

The high physical properties of N-A-X HIGH-TENSILE steel can help *you* increase your production . . . improve your product . . . reduce your fabricating costs.

MAKE A TON OF SHEET STEEL GO FARTHER

Specify—

N·A·X

HIGH-TENSILE STEEL

## GREAT LAKES STEEL CORPORATION

N-A-X ALLOY DIVISION • DETROIT 18, MICHIGAN

UNIT OF NATIONAL STEEL CORPORATION

## Plastic Preforms Processed Rapidly on New Preheater

A new 3-kw., 40-megacycle preheater for preheating of plastic preforms has been announced by the *Industrial Heating Div., General Electric Co.,* Schenectady 5, N. Y. Operating on 230 v., single phase, 60 cycles, the new preheater will heat 40 oz of wood-flour phenolic compound from 70 F to 250 F in 1 min.—or 1 lb. of this material in 24 sec. The integrated design of this preheater requires only 2¼ sq. ft. of floor space and is portable.

*Features of this plastic preheater include automatic operation and compact design.*

This preheater is provided with an automatic "pop-up" cover which facilitates preform loading and unloading. In addition, two timers with associated control permit operation alternately with two presses having different load requirements.

Another feature of this preheater is the incorporation of three meters, the dials of which are mounted on the front of the cabinet. One of these meters indicates the direct-current applied to the oscillator circuit, which is an indication of the rate of heat input to the preforms. Another shows safe operation of the oscillator tube. The third indicates either oscillator or rectifier filament voltage. Separate rheostats in the filament circuit permit proper voltage setting, thus assuring long tube life.

● A new baking enamel recently developed by *Maas & Waldstein Co.,* Newark, N. J., is suitable for use on the reflector panels of light fixtures. This material, known as Codur Gloss White Baking Enamel 68080, has proved satisfactory because of its high resistance to humidity and salt spray and because of its high light reflectivity. The company reports that it has 87% reflectivity and has withstood a 1000-hr. humidity test.

## New Portable Welding Head Produces Continuous Weld

A new portable welding head for arc welding which produces continuous welds using standard coated electrodes is being marketed by *Elge Associates*, 16 E. 71 St., New York 21.

According to the company, the machine produces faster and better welds than by hand welding methods since the arc is not interrupted during the automatic change of electrodes. The first model will weld sheet and plate and join right angle or oblique sections. Longitudinal welds on curved surfaces such as pipes and tanks can also be made.

The welder is equipped with controls and adjustments for fine adjustment of welding current, regulation of arc length, as well as vertical and horizontal adjustments. Carriage speed adjustments between 1 and 40 in. per min. are possible. Straight track is furnished with the welding head. Curved or circumferential track is easily fabricated. Electrode magazines may be refilled during the operating period.

The welder is light enough to permit moving and setting up by one man. The company claims the mobility and adaptability of the welder will permit its use for most welds that have heretofore required hand arc welding. Used in production, one operator can tend two machines for most work, it is claimed.

Electrode magazines designed to permit overhead welding will be available soon, according to the company. Another model for butt welding pipe and tube will also be available.

## Punch Cuts Samples from Strip for Test Purposes

A recently built drum type sample punch by *United Engineering & Foundry Co.*, Pittsburgh 22, has been designed to cut samples up to 4 in. in dia. out of steel strip 0.005 in. to 0.020 in. thick, running at speeds up to 2000 ft. per min. Similar machines are in the design stage to cut samples from strip up to 0.036 in. thick and at speeds approaching 4000 ft. per. min.

Applications for this punch are in cold mills, particularly skin pass mills, and processing lines such as electrolytic tinning lines. Samples taken on the fly are used for the rapid determination of physical properties and coating characteristics so that proper adjustments and compensations in the rolling and processing operations may be quickly made.

The sample punch consists essentially of two geared drums driven by a d.c. motor, powered from the Ward Leonard system of the mill so that the punch is at all times exactly synchronized with the movement of the strip. The upper drum has a fixed die and the lower drum a movable

# For "Trouble Free" Service Simplicity Engineering Company Specifies...

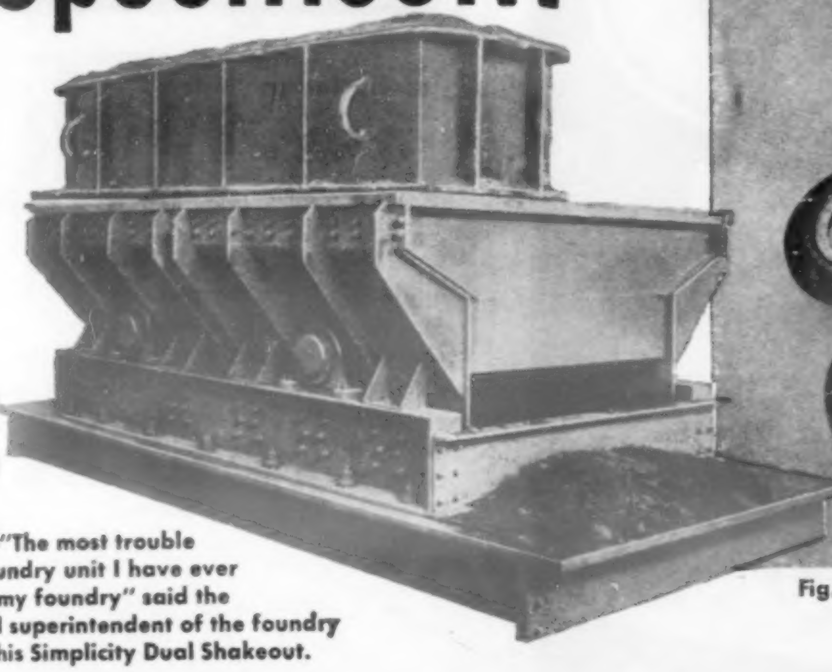


Fig. 2—"The most trouble free foundry unit I have ever had in my foundry" said the general superintendent of the foundry using this Simplicity Dual Shakeout.


Fig. 1—Some of the various Meehanite castings used in Shakeout units.

# MEEHANITE CASTINGS®

As builders of rugged foundry, coal, mining and materials' handling equipment—equipment which gives truly "trouble free" service under severe conditions, Simplicity Engineering Co., Durand, Michigan, use Meehanite castings (Fig. 1) to construct the operating mechanism of units like the 8′ x 10′ Dual Shakeout (Fig. 2).

The castings include:

1 Machine sheave
2 Shaft adapter for mounting sheaves
3 Grease retaining seals
4 Name and cover plate

Produced with the rigid control provided by the Meehanite manufacturing processes, these castings provide *better* engineering properties—contributing to the equipment strength, resistance to wear, toughness, soundess and uniformity.

*Write us for a copy of the Meehanite Handbook or send us your prints for an engineering analysis.*

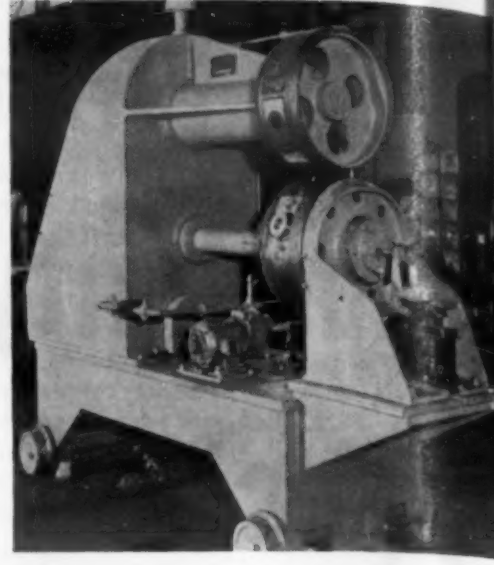
Meehanite®

PERSHING SQUARE BUILDING • NEW ROCHELLE, N. Y.

## MEEHANITE FOUNDRIES

| | |
|---|---|
| American Brake Shoe Co. | Mahwah, New Jersey |
| The American Laundry Machinery Co. | Rochester, New York |
| Atlas Foundry Co. | Detroit, Michigan |
| Banner Iron Works | St. Louis, Missouri |
| Barnett Foundry & Machine Co. | Irvington, New Jersey |
| E. W. Bliss Co. | Hastings, Mich. and Toledo, O. |
| Builders Iron Foundry Inc. | Providence, R. I. |
| H. W. Butterworth & Sons Co. | Bethayres, Pennsylvania |
| Continental Gin Co. | Birmingham, Alabama |
| The Cooper-Bessemer Corp. | Mt. Vernon, Ohio and Grove City, Pa. |
| Crawford & Doherty Foundry Co. | Portland, Oregon |
| Farrel-Birmingham Co., Inc. | Ansonia, Connecticut |
| Florence Pipe Foundry & Machine Co. | Florence, New Jersey |
| Fulton Foundry & Machine Co., Inc. | Cleveland, Ohio |
| General Foundry & Manufacturing Co. | Flint, Michigan |
| Greenlee Foundry Co. | Chicago, Illinois |
| The Hamilton Foundry & Machine Co. | Hamilton, Ohio |
| Johnstone Foundries, Inc. | Grove City, Pennsylvania |
| Kanawha Manufacturing Co. | Charleston, West Virginia |
| Koehring Co. | Milwaukee, Wisconsin |
| Lincoln Foundry Corp. | Los Angeles, California |
| The Henry Perkins Co. | Bridgewater, Massachusetts |
| Pohlman Foundry Co., Inc. | Buffalo, New York |
| Rosedale Foundry & Machine Co. | Pittsburgh, Pennsylvania |
| Ross-Meehan Foundries | Chattanooga, Tennessee |
| Shenango-Penn Mold Co. | Dover, Ohio |
| Standard Foundry Co. | Worcester, Massachusetts |
| The Stearns-Roger Manufacturing Co. | Denver, Colorado |
| Traylor Engineering & Mfg. Co. | Allentown, Pennsylvania |
| Valley Iron Works, Inc. | St. Paul, Minnesota |
| Vulcan Foundry Co. | Oakland, California |
| Warren Foundry & Pipe Corporation | Phillipsburg, New Jersey |
| Washington Machinery & Supply Co. | Spokane, Washington |
| E. Long Ltd. | Orillia, Ontario |
| Otis-Fensom Elevator Co., Ltd. | Hamilton, Ontario |
| U. S. Challenge Co. | Centerville, Iowa and Batavia, Illinois |

"This advertisement sponsored by foundries listed above."

*Drum-type flying sample punch with guards removed showing drums and solenoid controlling punch action.*

punch, which can be extended by means of a solenoid acting through a toggle linkage inside of the drum.

When the actuating button is pushed at the will of the operator, a sequence of operations is set in motion which controls the extension and retraction of the punch, so that only one sample is cut out even at the highest speeds. The machine can be made retractable so that samples can be taken at any point across the width of the strip, or fixed—as desired.

## Nut Fastener Handy for Thin Metal Sections

Where the application of nuts to bolts in production work is difficult due to lack of space, or where metal sections are too thin to thread, it is often possible to use projection weld nuts. The application process is then reversed, the nuts are welded in final position, and the bolt is screwed into the nut.

Trouble has frequently been encountered in the nut-welding process by particles of welding metal dropping into the nut threads during the welding process, requiring retapping of the nut. This trouble is said to be overcome in the 3-point projection weld nut developed by the *Grip Nut Co.*, 308-B So. Michigan Ave., Chicago 4, by counterboring the bottom of the nut about a quarter of the way through, causing metal particles to fall on the counterbored portion (which slants outward) instead of on the threads. The thickness of the weld nut is increased to compensate for the threads removed by counterboring, thread depth being the same as in a standard nut.

The top of the projection weld nut is the standard Gripco "double triangle" thread-locking design. When the bolt is applied, it locks into the nut and is prevented from loosening. The 3-point weld nut has three projections for welding contact, assuring firm, non-rocking electrical connections when making the weld.

## New Line of Broach Sharpeners Developed to Meet Varying Needs

A line of broach sharpeners, comprising some seven basic models, has been announced by the *Colonial Broach Co.*, Box 37, Harper Station, Detroit 13. The line includes two sizes of machines for sharpening flat broaches; three for sharpening "round" broaches; and two sizes of machines which will handle both flat and round broaches.

The flat broach sharpeners will handle broaches up to 8 in. wide and up to 32 in. and 65 in. long at one setting, respectively. The round broach sharpeners will take broaches up to 6 in. in dia. and up to 36 in., 72 in., and 84 in. long, respectively. They are designed to handle all types of "round" broaches—including spline, serration, and other types. The two "universal" models will handle round broaches having diameters up to 6 in. and up to 72 in. and 84 in. long, respectively. and flat broaches up to 8 in. wide and 65 in. and 77 in. long, respectively.

*One of the line of new broach sharpeners—the Universal model for round and flat broaches.*

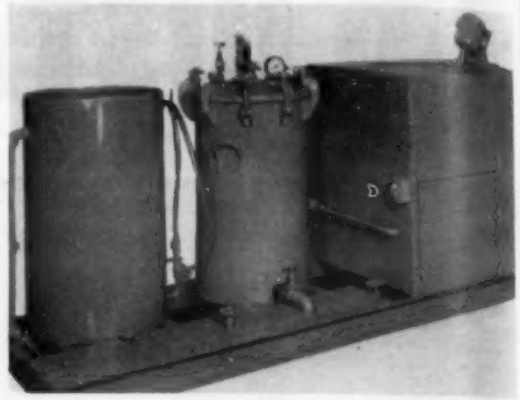
All grinding wheels and headstocks on these sharpeners are equipped with built-in motors. The spindles of the grinding wheels on all machines have a standard speed of 4000 rpm., which can be increased to a maximum of 10,000 rpm. through use of special pulleys. Headstocks on the machines for sharpening round broaches—as well as on the "universal" models—have 2-speed gearing for spindle speeds of 200 and 400 rpm.

## Vacuum and Pressure Unit Eliminates Porosity in Castings

A combination vacuum and pressure unit for eliminating porosity in pressure castings has been developed by the *Metallizing Co. of America*, 3520 W. Carroll Ave., Chicago. The new machine is a high efficiency circulator for use with a special metallic impregnating solution. All types of castings ranging from small bronze steam valves to fair-sized cast iron freon engine heads, outboard motor parts, carburetors, pressure castings of aluminum, bronze, stainless steel, and cast steel have been successfully impregnated.

The machine consists of a vacuum pump,

sealing tank, supply tank and agitator, heating elements, high pressure air connector, rinsing tank, and city water supply and drain connections. To commence operation, equal amounts of water and impregnating solution, known as Mogul Cast Seal B, are placed in this tank. The thermostat is set at 190 F and the mixture is heated. Meanwhile, the lid on the pressure



*A variety of pressure castings can be treated in this combination vacuum and pressure unit to eliminate porosity.*

tank is removed and the castings placed inside, the tank is closed and a vacuum is drawn and held.

The vacuum pump is in the lower part of the square tank. This pump line is shut off, air pressure of 90 lb. is put in the tank and held for 15 min. and the castings are then ready for removal from the sealing tank. They are placed into the tank on the left, where they are rinsed so that when the process is finished, there is no sign of any seal adhering to their surface.

● *Consolidated Molded Products Corp.*, 309 Cherry St., Scranton 2, Pa., have announced the development of a handle for vacuum-type coffee makers. The handle is molded of phenolic plastic with asbestos-filled, heat-resistant, high impact strength qualities.

## Light-Duty Stamping Trimmer for Mild Steel

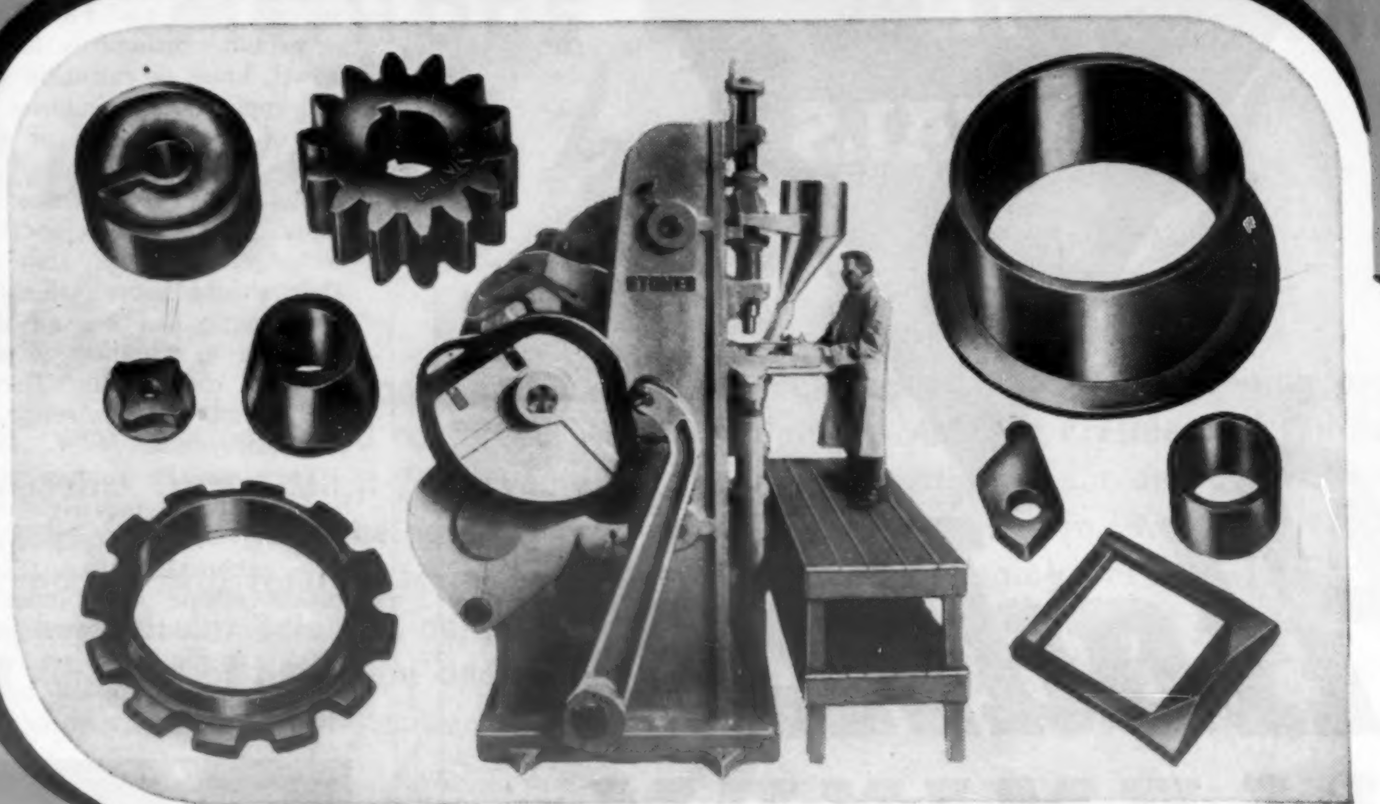
Development of a new light-duty stamping trimmer for cutting up to 1/16-in. mild steel has been announced by the *Whiting Corp.*, Harvey, Ill.

This new model is an adaptation of its standard heavy-duty machine. It was designed primarily to bring the benefits of machine trimming to the smaller shops and those handling small runs on a job-shop basis. Provision has been made in the machine for constant or variable-speed drive, as preferred.

Drive is through a differential type transmission which permits the use of rolls or cutters of different diameter without variation in peripheral speed.

ASK STOKES

# Design in Powdurgy* to Save High Labor Costs



Stokes P-3 press (80 tons pressure) and typical powder metal parts

DESIGN for Powdurgy production to save on casting, machining, and material. Design for automatic compressing to reduce operating-time to the vanishing point.

Remember that powder metals, like any new material, can be a disappointing delusion in uninformed hands. Therefore, at every point of planning ask Stokes engineers to help you from the documented experience of more than 25 years in powdurgy production.

Stokes machines, in 1926, made the first porous metal bearings; then the cemented carbides, both now made chiefly on Stokes machines. Then came electrical, and more recently, electronic parts. Stokes has also developed the vacuum impregnating methods and equipment which fill porous bearings with the maximum amount of lubricant.

Stokes experience and demonstration laboratory are at your service. Consultation is invited.

F. J. Stokes Machine Company, 5972 Tabor Road, Philadelphia 20, Pennsylvania.

FJS

*Stokes makes Vacuum and Special Processing equipment, High Vacuum Pumps and Gages, Industrial Tabletting and Powder Metal Presses, Plastics Molding Presses, Pharmaceutical equipment, Water Stills and Special Machinery.*

*Stokes word for the theory and practice of making finished solid products from granular materials.

STOKES KNOWS HOW

## Thermal Barrier Materials Withstand Temperatures Up to 2800 F

Two new thermal barrier materials capable of withstanding temperatures as high as 2800 F have been added by the *American Latex Products Corp.*, 921 Venice Blvd., Los Angeles 15, Calif., to their line of adhesives and sealing compounds.

The new sealing compounds, known as Stabond FR 8 and FR 10, are obtainable in various consistencies for application by trowel, brush or extrusion gun and should find application in industry where a problem of heat resistance or exchange exists.

The new compounds are particularly suitable for application as an insulating material to electrical junction boxes, heat exchanger couplings and similar points. They should prove valuable for lagging steam pipes and hot air ducts wherever resistance to vibration as well as heat is a desired characteristic. They may also be used as an abrasion resistant coating for electrical systems.

These sealing compounds are thermal barrier materials, initially of a plastic nature, and may be used for filleting or applied to a spherical surface. They "cure" by solvent release at approximately 80 F, forming a hard but not inflexible sheath which may be given greater resistance to air and flame abrasion by incorporating additional support, such as perforated glass

*Testing the new thermal barrier material; a flame is being played on a ½-in. thick layer on a backing of aluminum sheet which is held on a demonstrator's bare hand.*

cloth or similar material, at the time the sheath is formed.

The one compound, FR 8, resists temperatures up to 2000 F; while FR 10 has properties similar to those of FR 8, it is made of materials having a greater refractive power and has been tested at 2800 for 15 min. with satisfactory results. It is capable of withstanding considerably high temperatures intermittently.

● Production of "golden" plate glass has been undertaken by *Libbey-Owens-Ford Glass Co.*, Nicholas Building, Toledo, Ohio. This glass excludes more than 99% of the ultraviolet rays in sunshine without noticeably impairing vision or greatly reducing light transmission. One of the most recent uses has been in television protective screens to filter out ultraviolet light.

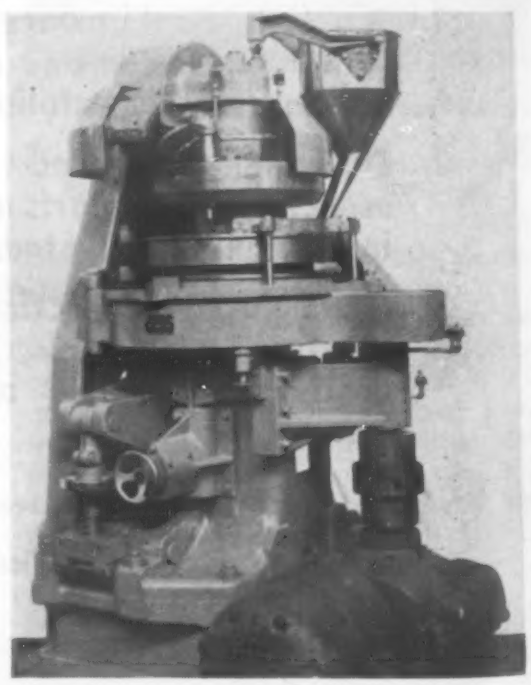
## Wire Control and Straightener Unit for Metallizing Work

A new wire control and straightener unit has been introduced by the *Metallizing Engineering Co., Inc.*, 38-14 30th St., Long Island City 1, N. Y.

Some of the features of the unit include: (1) all metal construction; (2) outer metal hoop keeps the coil on the reel and prevents the wire from "riding off", or getting tangled under the arms; (3) ball type thrust bearing makes it free running and eliminates all unnecessary drag from reel top; (4) all adjustable parts are equipped with thumb screws for quick and easy adjustment; (5) assembled in 10 min.; (6) adapted to mounting on automatic set-ups, bench or other desired place; and (7) wire moves on sealed grease packed, ball bearing rollers. Unreels wire in proper direction and removes curvature from any type or any size metallizing wire, regardless of stiffness. One adjustment feeds the wire in any desired direction.

## High-Speed Powder Metal Press Has 30-Ton Capacity

A new 30-ton rotary press has been announced by the *F. J. Stokes Machine Co.*, 5972 Tabor Rd., Philadelphia, for making powder metal parts at high-speed production rates. The press will produce from 65 to 91 powdered metal parts per min., depending upon the pinion used; two sets of pinions are furnished with the press. Production of parts up to 2½ in. in dia. with a die fill of 4¼ in. is possible. Normally equipped with a 12-station head, a greater number of punch stations can be provided for special jobs, thus increasing production proportionately. Flanged parts can also be produced through the combination of a mechanism for moving the upper pressure



*Powdered metal parts at the rate of 65 to 91 per min. are produced with this press.*

(Continued on page 140)

roll up or down in a vertical plane, and a special arrangement of cams.

Powered by a 20-h.p. constant speed motor, the press, Model No. 230, applies 30-ton pressure from both above and below simultaneously. Other features include pressure equalizer and excess pressure release; double lifting cams for upper punches; core rod attachments; and, upper and lower punch bushings.

F. J. Stokes Machine Co. also recently announced a new dual-pressure preformer. By means of a floating die table, pressure is applied from both top and bottom at the same time to produce preforms of uniform density throughout. Power-application is so arranged that the press cannot jam, nor can it rest on dead center. Preforms are produced up to 4 in. in dia. with a die fill of 2⅝ in. Large die area permits making irregular and rectangular pieces up to 6 in. in length and 4 in. in width.

● A new electrode, marketed by the *Hobart Brothers Co.,* Hobart Square, Troy, Ohio, is a low hydrogen coated electrode designed for welding high carbon, high sulfur and other hard-to-weld steels without underbead cracking. The absence of underbead cracking is said to be achieved by a special low hydrogen coating. Physical properties of this electrode are: tensile strength 94,000 lb. psi., yield point 85,000 lb. psi. and 26% elongation in 2 in. The electrode is available in 3/32 in., ⅛ in., 5/32 in., 7/32 in., and ¼ in. dia. for use with d.c. welding current only.

## Ball Bearing Action Built into Tube Cutter

A new tube cutter designed for use with copper, brass, aluminum, Bundy steel, block tin and lead tubing, hard or soft temper, is available from the *Imperial Brass Manufacturing Co.,* 1200 W. Harrison St., Chicago 7. It will cut all sizes from ⅛- to 1-in. outside dia., inclusive.

One of the features listed for this tool is its "free wheeling" action. Ball thrust bearings are built into the tool to provide ease of operation and to make possible fast size adjustment. Tubing being cut rolls on rollers. There is a flare cut-off groove in the rollers which makes it possible to remove a cracked flare without waste of tubing.

Another feature is the retractable locking reamer for reaming tubing after it is cut. The reamer folds out of the way when not in use. Feed mechanism of the tool is enclosed so that threads are protected against dirt and damage. Body is high strength aluminum alloy and the tool weighs only 6 oz.


# OILITE FINISHED MACHINE PARTS

With the shortage of castings, stampings and forgings, manufacturers look to Amplex for OILITE finished machine parts, from metal powder, replacing those materials. Very frequently Amplex furnishes OILITE finished machine parts, through powder metallurgy, at a saving. Other advantages of OILITE parts are short tool up time, quick delivery, improved appearance, and the incorporation of details of design not machinable by production machine tools.

*Send your blueprints to Amplex Field Engineer or the Home Office. Address Dept. E.*

## AMPLEX MANUFACTURING CO. DETROIT 31, MICHIGAN

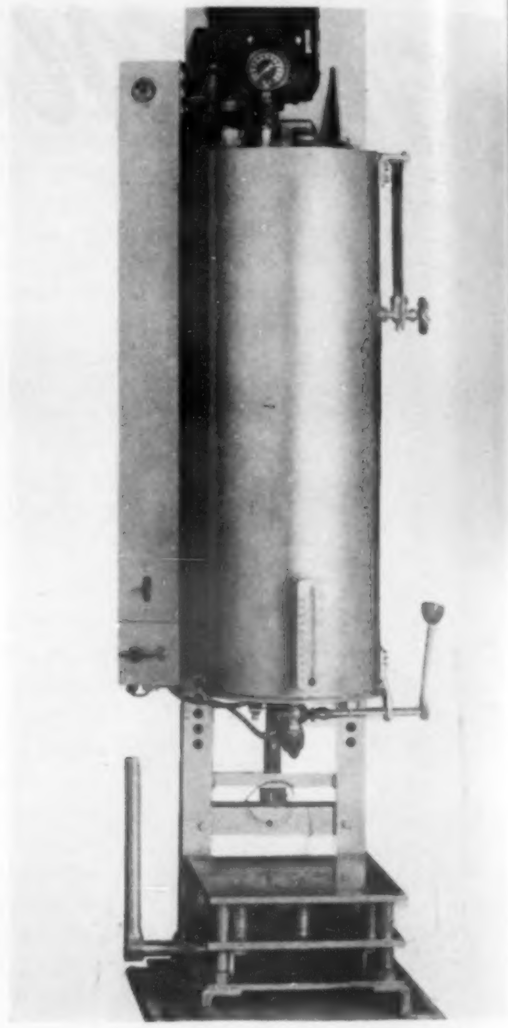
*Division of Chrysler Corporation*

FIELD ENGINEERS AND OILITE BEARING DEPOTS IN PRINCIPAL CITIES

## Wax Injector for Precision Casting

A new wax injector for use in precision casting shops has been announced by I. *Shor,* 64 W. 48 St., New York 19. The injection unit is motor operated.

The mold table is manually brought up to the injection nozzle by means of a lever. The wax is heated by immersion heaters,



*This wax injector unit is designed for use in precision casting shops.*

and the nozzle temperature is carefully controlled.

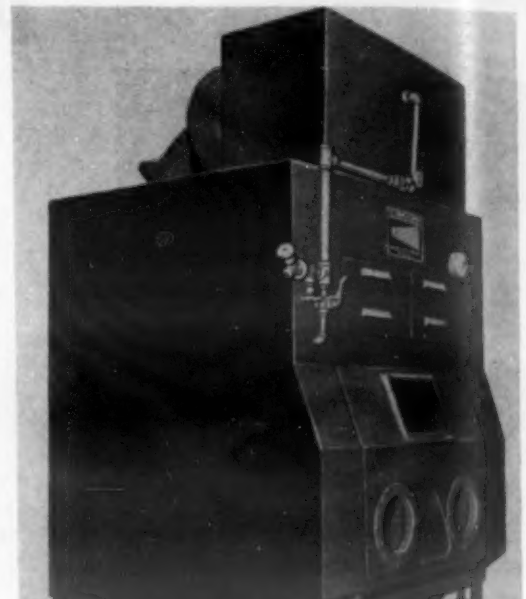
The standard maximum temperature is 210 F, and the maximum pressure is 300 psi. Higher temperatures and pressures can be had if desired. The maximum volume per injection is approximately 635 cu. in., maximum mold size is 13 by 13 by 16 in. Overall dimensions of the unit are 14 by 13 by 72 in. high.

## Cleaning and Finishing Machine Uses Wet Abrasive Principle

A new machine for wet abrasive blast cleaning and finishing of metal surfaces is now available from *Armstrong Chemical & Machine Co.,* Painesville, Ohio. The machine removes rust, scale and undesirable metal particles, such as feather edges on sharpened tools, by projecting a slurry of fine abrasive suspended in water against the surface to be cleaned. The permissible variation in abrasive size (60 to 1250 mesh) makes it commercially possible to produce finishes as low as 2-3 micro-inches r.m.s.

The method is said to produce a matte

finish with practically no removal of metal. Specifications of the standard models are: a 30- by 30-in. cabinet, 77 in. high, one blast nozzle and exhaust blower directly connected to a ¼-h.p. motor; and a 48- by 42-in. cabinet, 108 in. high, one to eight blast nozzles and exhaust blower



*This jet blast metal cleaning machine has a capacity to operate with one to eight blast nozzles.*

directly connected to a 1-h.p. motor. Cabinet and frame are welded steel construction.

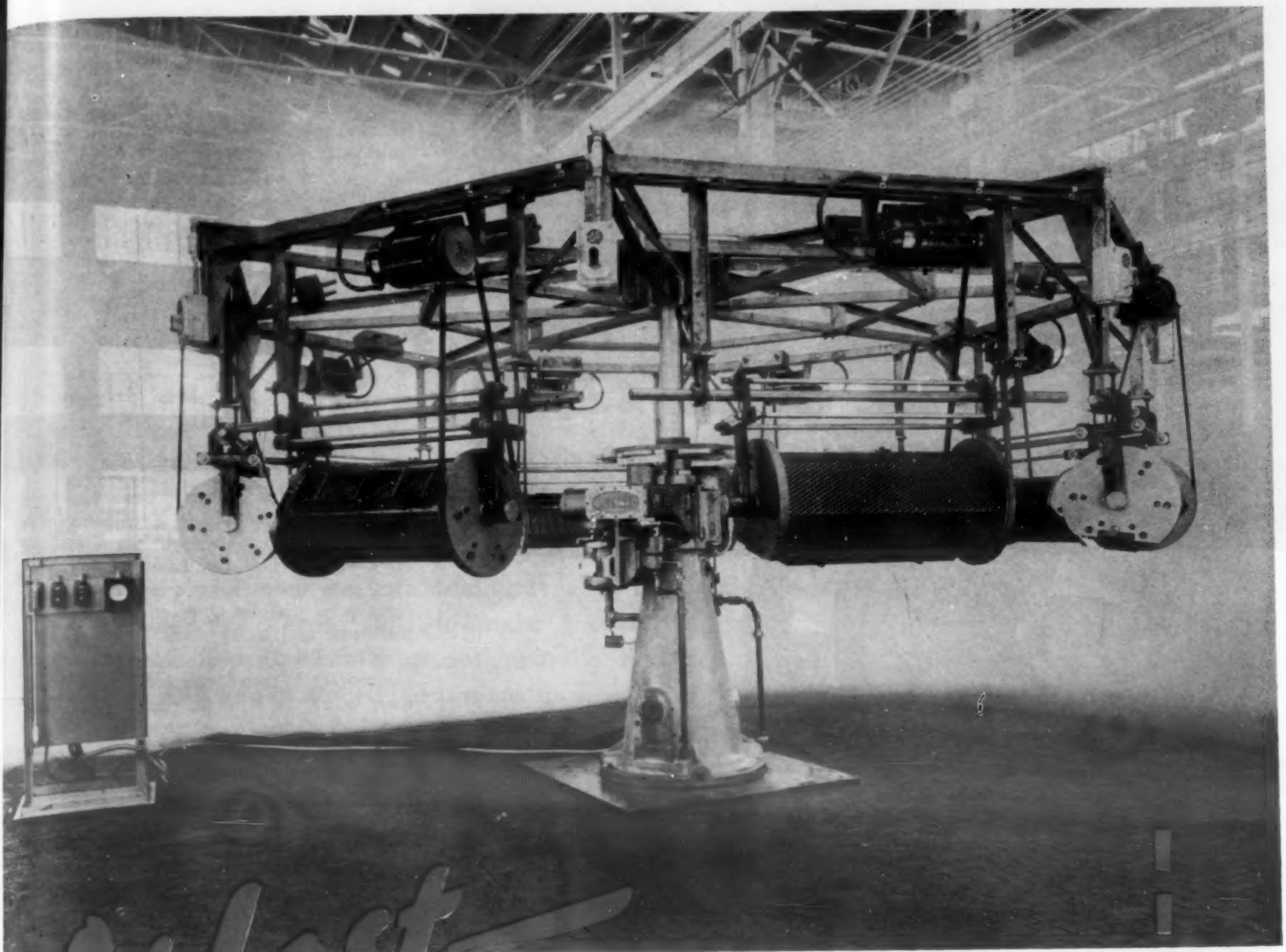
The siphon jet principle is used for transferring the grit slurry, thus eliminating any pumps or moving parts coming into contact with the abrasive liquid. The only wearing parts are the blast nozzles. Typical applications of the cleaning machine are removal of rust, mill scale and heat treating scale; cleaning forging dies and metal molds; honing metal cutting tools; and preparation of metal parts for plating, painting or enameling.

## New Ferromagnetic Materials for Electrical Parts

New magnetic ferrite materials, which are said to have properties permitting a considerable reduction in the physical size of electrical components such as inductors and transformers, are now available from *Philips Laboratories, Inc.,* Irvington-on-Hudson, N. Y.

These magnetic ferrites, known as Ferroxcube, consist essentially of homogeneous mixed crystals of metallic oxides and iron oxide. They have magnetic permeabilities and low remanence and coercivity. In contrast with the usual magnetic materials, which are highly conductive, the new materials are said to be essentially electrically insulating.

The properties of these materials make



# At last

# AN AUTOMATIC CONVEYOR FOR HORIZONTAL BARRELS!

Here's the first fully automatic machine for conveying continuously rotating horizontal barrels through electrified or unelectrified treatments. Just the thing for pickling, plating, Bullard-Dunn Process descaling, phosphating, chromate dipping, blackening, heat treating, and other sequences. Reduces costs, accurately times treatments, expedites production. Surprisingly low in price.

**ENGINEERED TO YOUR SPECIFICATIONS.** This Bullard-Dunn Station-Type Conveyor is engineered to your specifications. We will give you exactly what you want in number of stations and arms, length of arms, load, lift, transfer speed, etc.

**FACTS ABOUT BARRELS.** Standard barrels are available and special designs will be made as required. Can be used for both acid and alkali solutions and also for high temperature salt bath treatments.

Barrels are rotated when in and out of tanks by means of V-belt or gear drives, with separate push-button controls for each barrel.

Both barrel work and racked work can be conveyed on the same machine and different voltages for each can be automatically obtained. An adjustable dwell period at the high position permits the continuously rotating barrels to drain completely before indexing begins.

**WRITE FOR COMPLETE DATA.** This Bullard-Dunn Station-Type Conveyor is fully described in Bulletin MM-BD-45. Write for your copy today. THE BULLARD COMPANY, Bullard-Dunn Process Division, Bridgeport 2, Connecticut.

**BULLARD**

**BULLARD-DUNN DESCALES WITHOUT DIMENSIONAL CHANGE**

The Bullard-Dunn Process removes scale and oxide from ferrous metallic surfaces without attacking the work. Fast . . . thorough . . . economical . . . simple to operate. Investigate. Bulletin MM-BD-46 tells the story.

them suitable for high-frequency inductance coils, radio transformers and other electromagnetic apparatus. By use of these materials it is reported that coils have a quality coefficient many times greater than conventional coils and at the same time a substantial reduction in the volume of the coil is realized. Ferroxcube is currently being used as the 25-Kv. transformer for the Protelgram projection television system in which its size is only 1¾ in. in dia. and 1⅛ in. thick.

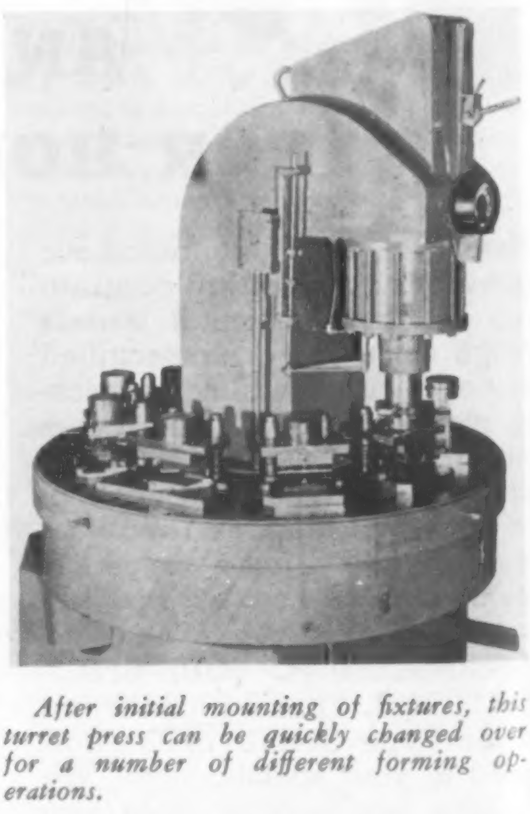
## Quick Change-Over Possible with New Turret Press

A new hydraulic turret press has been announced by the *Rettig Engineering Co.* to be distributed through the *Universal Air-Line-Joint Mfg. Co.*, Lafayette, Ind. This press was designed to meet the demand for a press that would practically eliminate tear-down and set-up time.

It has a large turret table that will accommodate as many set-ups (depending on their size) as will fill the table. After initial mounting of fixtures, the operator can change from one fixture to another whether the operation is blanking, forming, drawing, swedging, assembling, etc.

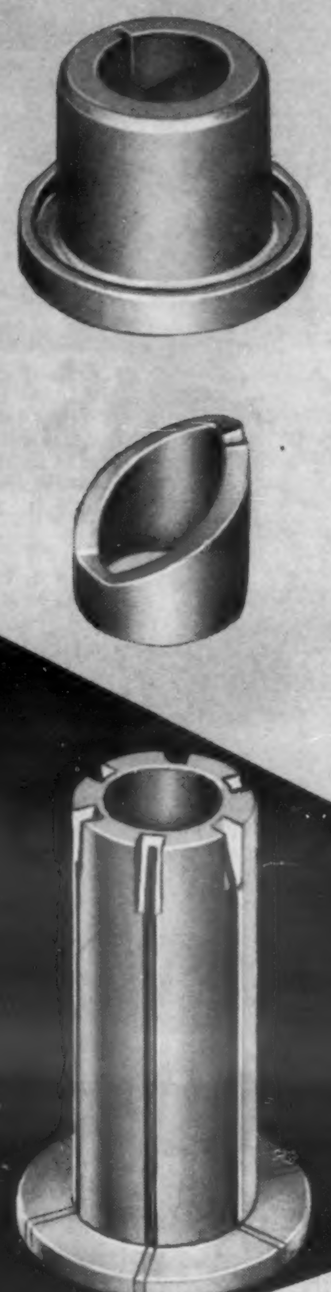
These presses are built in three sizes—10- 20- and 30-ton—and may be operated either automatically or manually. The turntable is rotated by manual operation. The press, frame and turret table are fabricated steel. Turret table is mounted on rollers.

The turret table is 48-in. O.D. and 20-in. I.D. Ram stroke (either manual or automatic operation), maximum 4⅛ in. and ¼-in. minimum. Turret table to ram dimensions, maximum 10¼ in., minimum 6⅛ in. Slug clearance hole in bolster plate, 4½ in. by 4½ in. Projected floor space, 48 in. by 56 in. Height of turret table from floor 37¼ in. with overall height 83½ in.



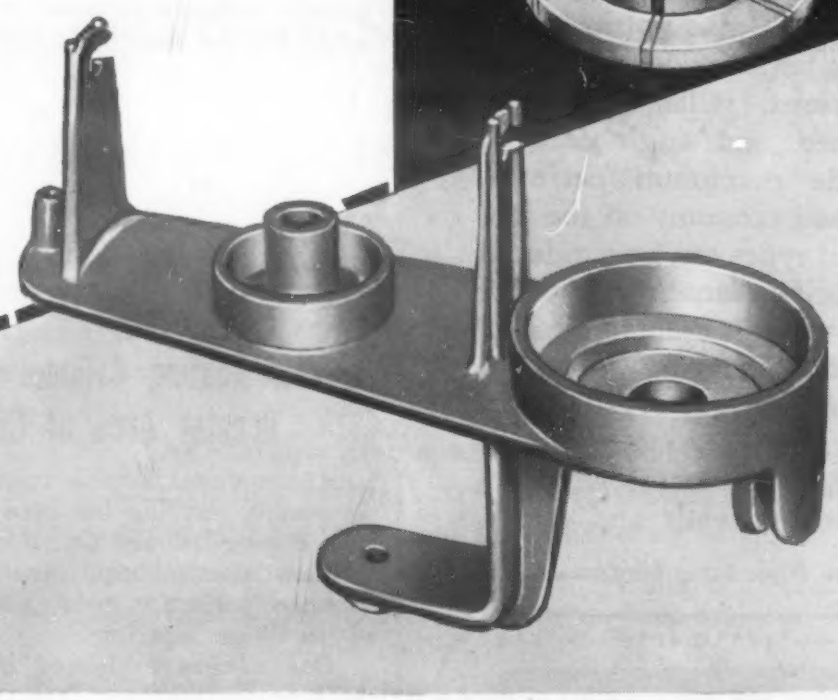
*After initial mounting of fixtures, this turret press can be quickly changed over for a number of different forming operations.*

# A DESIGN ESSENTIAL MADE POSSIBLE BY *Madison-Kipp* DIE CASTINGS



***The*** designer of Hobby Knit which "opens a brand new era of handicraft art" required close tolerance needle slots to make his knitter perform properly. Madison-Kipp designed the die to cast the slots and produced the zinc castings.

Engineers and designers often find helpful co-operation by Madison-Kipp craftsman whose life work has been the practical application of die castings to new uses.

## MADISON-KIPP CORPORATION

218 WAUBESA STREET, MADISON 10, WIS., U.S.A.

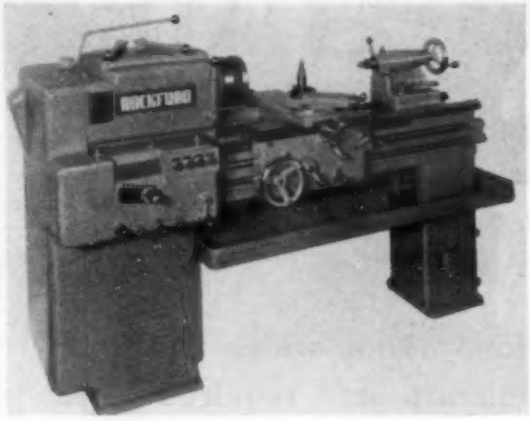
ANCIENS ATELIERS GASQUY, 31 Rue du Marias, Brussels, Belgium, sole agents for Belgium, Holland, France, and Switzerland.

*WM. COULTHARD & CO. Ltd., Carlisle, England, sole agents for England, most European countries, India, Australia, and New Zealand.*

- *Skilled in* DIE CASTING *Mechanics*
- *Experienced in* LUBRICATION *Engineering*
- *Originators of Really High Speed* AIR TOOLS

## General Purpose Medium Size Lathe Has 12 Spindle Speeds

A medium size, general purpose lathe has been introduced to the machine tool industry by the *Rockford Machine Tool Co.*, Rockford, Ill. The new lathe has an all-geared headstock, with a range of 12 spindle speeds, all adjustable by means of conveniently located levers. The spindle is made from a high alloy steel forging, mounted on Timken zero-precision bearings.



*This engine lathe is designed for the medium priced field.*

Overall design of the headstock permits all types of lathe operations, including high spindle speeds and the use of tungsten carbide cutting tools. Pick-off change gears, reverse gears, V-belts and similar parts and assemblies are accessible for adjustment or repair through the hinged door on the headstock end of the lathe. All moving parts, with the necessary exception of the spindle nose, are protected to provide full safety for the machine operator.

## New Heating Cylinder Provides Greater Area of Contact

An improved heating cylinder for thermoplastics molding has been perfected by the *Watson-Stillman Co.*, Roselle, N. J. It is now standard equipment on all this company's injection molding machines from 4- to 80-oz. capacity.

One advantage claimed by the manufacturer for this new design is its ability to deliver capacity shots of such "de-rating" materials as polystyrene without stuffing. All surfaces in contact with plastic are chromium plated; the injection plunger is made of Nitralloy and is internally water cooled to prevent scoring or sticking.

The new nozzle adapter is secured by a tapered acme thread and seats firmly against maximum operating pressures. It permits rapid dismantling of nozzle and torpedo for cleaning with cylinder in place. Calrod units provide the heat, and are set in grooves around the cylinder, thereby considerably increasing the area of contact and the consequent rate of heat transfer.

**U·S·S STAINLESS SAFETY VALVE FOR TANK CARS**

Made of Stainless to resist attack by corrosive gases and liquids during shipment and to maintain positive action in valve operation. The valve seat is machined from a U·S·S FM forging; the valve stem is made of our newly developed U·S·S Stainless W — heat treated, after forging, to a hardness of approximately 400 Brinell and then machined.

**U·S·S STAINLESS STEEL GAS CYLINDER FOR GARAND RIFLE**

Close precision is a must in the mass production of this vital part, which must have high strength and must offer high resistance to the heat, corrosion and abrasion caused by the rapid-fire action of this gun. U·S·S 12 FM was selected because it meets all these requirements.

# These precision parts

**U·S·S STAINLESS STEEL FOR SANITARY FITTINGS**

Fittings like this 3-inch nut, used in piping for milk and other liquid foods, must be leakproof. But they must also be easily assembled and taken down for frequent cleaning. This requires close tolerances which are met on a production basis with U·S·S 18-8 FM.

## are economically machined from Stainless Steel

## *...on high production schedules!*

● Since the introduction of free-machining U·S·S 18-8 FM and U·S·S 12 FM, many parts like these in which smooth finish and close tolerances are mandatory, are being turned, milled, drilled, tapped and threaded on automatic machining equipment, at cutting rates that approach those used on Bessemer screw stock. It's happening in hundreds of production machine shops throughout the country.

So forget that old chestnut about Stainless being hard to machine. Just remember this . . . that machining Stainless Steel is not difficult—only different . . . that with free-machining U·S·S 18-8 FM and U·S·S 12 FM, which give you high corrosion resistance and high strength plus machinability, you can machine any pattern that can be machined from ordinary Bessemer screw stock. And you can do it easily and economically.

Our Stainless Steel specialists have thoroughly investigated cutting rates, tool materials, lubricants and the effects of special tooling set-ups on various operations. If you want the benefit of their cooperation, it is freely at your service.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
CARNEGIE-ILLINOIS STEEL CORPORATION, PITTSBURGH & CHICAGO
COLUMBIA STEEL COMPANY, SAN FRANCISCO · NATIONAL TUBE COMPANY, PITTSBURGH
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
UNITED STATES STEEL SUPPLY COMPANY, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS

# U·S·S STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

8-1395

UNITED STATES STEEL

# *News of...* ENGINEERS COMPANIES SOCIETIES

## Engineers

The newly created position of general sales manager of the Federated Metals Div., American Smelting & Refining Co. was accepted by *A. M. Callis.* He was formerly sales manager of the Chicago territory, this capacity now served by *J. W. Kelin.* Succeeding Mr. Kelin as sales manager of the St. Louis territory is *Paul H. Jackson,* who was district sales manager at Seattle.

The Harbison-Walker Refractories Co. has announced the retirement of *Herman B. Campbell,* vice president in charge of operations, after 44 years of service with the company.

*Frank B. Powers* is now associated with the American Car & Foundry Co. as assistant vice president, Production Dept. He was formerly connected with the Baldwin Locomotive Works.

Several appointments were made recently at the General Electric Co. which resulted in the promotion of *Vernon L. Cox* to manager of engineering for the Switchgears Divs. He succeeds *C. H. Black,* who is now manager of engineering of the Construction Materials Divs. *A. F. Vinson,* formerly assistant production manager of the Apparatus Dept., is manager of the Welding Divs. Assisting Mr. Vinson are *C. I. MacGuffie* and *R. C. Freeman* as manager of sales and manager of engineering, respectively. In the Chemical Dept., Dr. *Charles E. Reed* has become engineering manager; *Robert L. Gibson,* assistant general manager; *Harry K. Collins,* manager of the Plastics Div.; and *John L. McMurphy,* manager of the Chemicals Div.

The election of *Porter S. Kier* as secretary of the American Cladmetals Co. occurred last month. Mr. Kier had been assistant secretary, assistant treasurer and director of the company.

The American Brake Shoe Co. has named *Gordon A. Weller* assistant manager of Replacement Sales and *Frank A. Colosimo* chief service engineer of its American Brakeblok Div.

*Harry P. Smith* has been named assistant general manager of sales of the Mathieson Chemical Corp. Mr. Smith formerly was sales manager of the New York district.

The appointment of *Robert W. Stokes* as sales manager of W. T. LaRose & Associates, Inc. took place recently. Mr. Stokes was formerly Eastern district manager of the Girdler Corp.'s Thermex Div.

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A new member of the metallurgical staff of Technical Metal Processing, Inc. is *Warren A. Silliman,* who had been the chief metallurgist of the Cletrac Div. of the Oliver Corp.

The election of *M. A. Follansbee* as president and *C. E. Christman* as chairman of the Board of the Follansbee Steel Corp. followed the recent death of *Lauson Stone,* who had held both these positions.

*R. E. W. Harrison* has resigned as vice president of the Chambersburg Engineering Co. to reestablish his consulting service, with headquarters in New York City. Specializing in management engineering, he will undertake assignments similar to those handled by the former business of Clarke-Harrison, Inc., of which he was vice president.

The promotion of *George R. Milne* to operating manager of the National Carbide Corp. was announced recently. At the same time, *Russell T. Lund* was made assistant operating manager.

The Libbey-Owens-Ford Glass Co. has named *Horton Spitzer* as director of sales of its Plaskon Div. *Whiting N. Shepard* succeeds Mr. Spitzer as general sales manager. Another change resulted in the Chicago area being divided into two sections, with *James Ferguson* as district manager of Zone 1, south of Chicago and the Chicago office, and *G. T. Walker, Jr.* managing Zone 1, north of Chicago.

The election of Dr. *Harry K. Ihrig* to the position of vice president and director of laboratories of the Globe Steel Tubes Co. took place recently. Another new vice president in the company is *Lee Mullen,* who will be in charge of sales. Mr. Mullen previously retained the position of general manager of sales.

Several appointments occurring at the Jessop Steel Co. include that of *Frank B. Rackley* as vice president in charge of sales. Mr. Rackley formerly was general manager of sales. *Curtis A. Gordon* was promoted from general works manager to vice president in charge of operations. *Carl J. Murray* is now general superintendent. He was formerly assistant manager of the Colorado Fuel & Iron Corp. *Edward J. Sherrill* has become superintendent of production scheduling and shipping. Mr. Sherrill held the same position with the Colorado Fuel & Iron Corp. Previously a plant engineer and engaged in personnel work at the Chevrolet plant, *Ellsworth E. Seitz* has accepted the position of director of personnel relations at Jessop. *Norris B. McFarlane* is now superintendent of the electric furnace department, having held the same position at Universal-Cyclops Steel Corp. *Edwin C. Thomas, Jr.* was named superintendent of the bar mills. He was formerly assistant superintendent of the rolling mills at Atlas Steels, Ltd. And *James O. McDowell* was made super-

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intendent of the sheet mills, the same position he held previously at the International Nickel Co.

*William Furber Smith* has joined the U. S. Testing Co., Inc. to organize a new engineering inspection service in conjunction with building and building material. Mr. Smith formerly served in the capacity of engineering director of the Manhattan Project War-Time Research Unit of the Carbide & Carbon Chemicals Corp.

The newly created position of comptroller of the Purchasing & Traffic Div. of the Western Electric Co. has been accepted by *Paul L. Palmerton,* who previously was assistant to the president.

The Ward Leonard Electric Co. has announced the resignation of *Dawson J. Burns* as president and his election as chairman of the Executive Committee. *Arthur A. Berard,* formerly executive vice president, succeeds Mr. Burns as president and retains his title of general manager.

The election of *A. H. Behnke* as vice president in charge of materials of Hotpoint, Inc. took place recently.

*Marcus E. Borinstein* has been named vice president as well as general manager of the Western Div. of James Flett Organization, Inc. Mr. Borinstein previously served as manager of ferrous and nonferrous scrap merchandising for the company.

The Inland Steel Co. has extended *Wilfred Sykes'* term of office as president from his normal retirement date of Dec. 31, 1948, until the annual meeting of the board of directors on Apr. 27, 1949. Other appointments included that of *Clarence B. Randall* as assistant to the president. *P. D. Block, Jr.* succeeds Mr. Randall as vice president in charge of raw materials, and *H. W. Johnson* was named vice president in charge of steel manufacturing.

The appointment of *James R. Longwell* as assistant to the president of Carboloy Co., Inc. has just been announced. *F. C. Ritner* succeeds Mr. Longwell as vice president in charge of engineering and research.

*George C. Delp* has been elected a vice president of the Sperry Corp. Mr. Delp also holds the position of president of the New Holland Machine Co., a subsidiary of Sperry.

Mack Trucks, Inc. has promoted *T. J. Zeller* to factory manager of its Allentown, Pa. plant. Mr. Zeller succeeds *C. J. Moran,* who has been transferred to the company's Western sales headquarters. *A. C. Schliewen* is now manager of Mack's Plainfield, N. J. plant, succeeding Mr. Zeller.

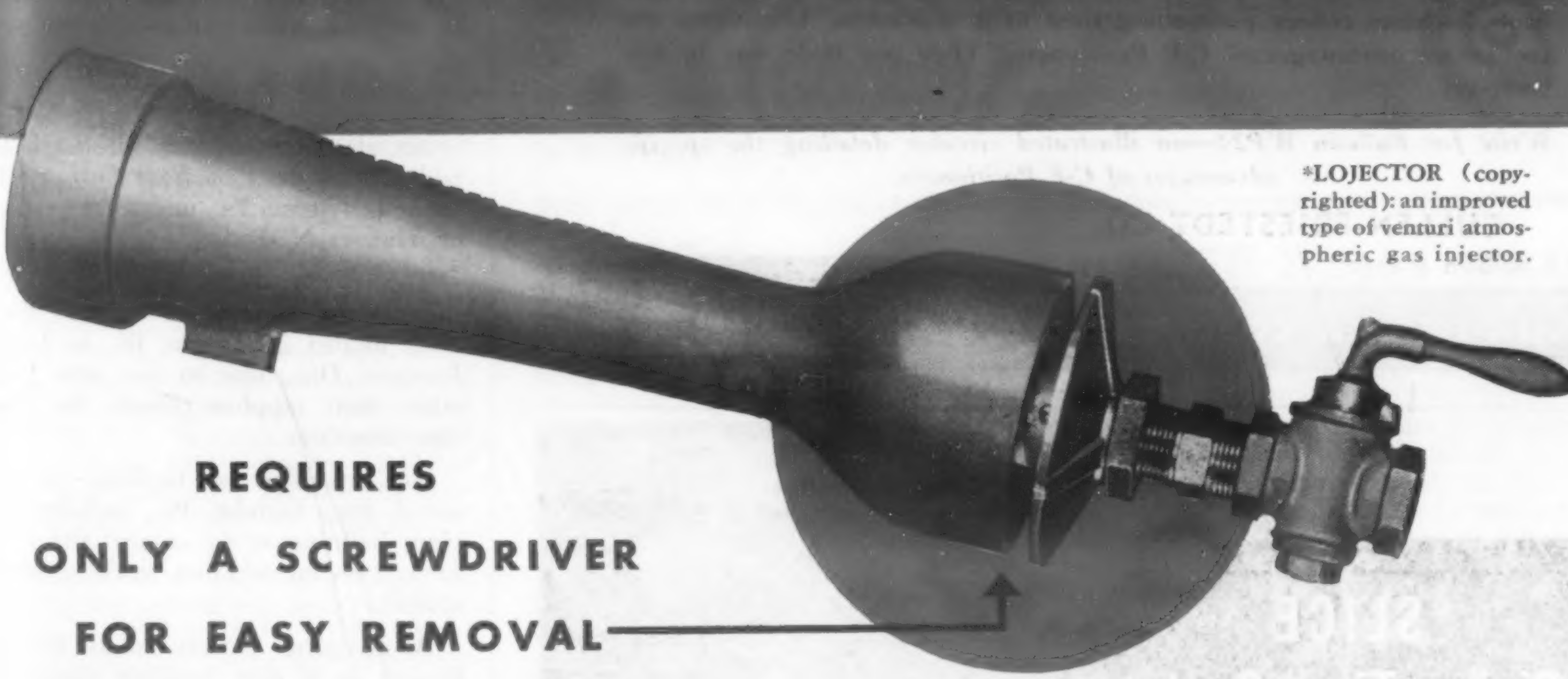
The appointment of *Lyman Thunfors* as vice president and general manager of the Paul M. Wiener Foundry Co. took place

*(Continued on page 158)*

# Quick changes are easy...

# the Bryant LOJECTOR*

## OFFERS CONVENIENCE IN SPUD CHANGING OR CLEANING



*LOJECTOR (copyrighted): an improved type of venturi atmospheric gas injector.

**REQUIRES ONLY A SCREWDRIVER FOR EASY REMOVAL**

All atmospheric gas injectors require an occasional spud changing or cleaning. One of the many advantages of Bryant Heater's Lojector is the convenience of the "slip-fit" orifice spindle. The spindle is fitted into the body and locked with a simple set screw. Requires no gadgets, no special wrenches for removal—only a screwdriver.

**These are other Lojector features:**

1. Improved design assures high entrainment capacity.
2. Standard pipe thread orifice spud.
3. Handy "cast-in" support boss.
4. "No-slip" wrench lugs for easy installation or removal.
5. Rugged, heavy-duty construction.

**Look into the advantages of the Bryant Lojector today!**
For complete details and specifications, write Industrial Division, Bryant Heater Company, 1020 London Road, Cleveland 10, Ohio.

INDUSTRIAL DIVISION
GAS COMBUSTION FOR INDUSTRY
*Bryant Heater Company*
• ONE OF THE DRESSER INDUSTRIES •

*News of...* ENGINEERS COMPANIES SOCIETIES

recently. Mr. Thunfors succeeds *William G. Grant,* who will continue to serve the company in an advisory capacity.

*Edward B. Yancey,* a leading figure in the explosives industry, died of a heart attack on Oct. 24. Mr. Yancey was a vice president and member of the board of directors and of the executive committee of E. I. duPont de Nemours & Co. (Inc.).

The National Radiator Co. announces the death of *Robert Wray Porter,* who had served as assistant to the president of the company in addition to conducting special surveys and market studies.

## Companies

An aluminum alloy plant has been established by the *Vanadium Corp. of America* at Eddystone, Pa., under the supervision of Thomas N. Peck.

The *Elgin National Watch Co.* has changed the name of its *Sapphire Products Div.,* located in Aurora, Ill., to *Industrial Products Div.,* due to the new products other than sapphire which the division now fabricates.

An expansion of facilities at *Kennametal, Inc.,* Latrobe, Pa., includes a new plant building at the rear of the property as well as an addition made to the laboratory.

A complete demonstration laboratory, housed in a new building designed expressly for development, research and test work on new equipment, and demonstrations and application studies for customers and prospects, has been erected by *C. I. Hayes, Inc.,* Providence, R. I.

The national headquarters of the *United States Steel Supply Co.,* warehousing subsidiary of the *United States Steel Corp.,* has been moved to 208 S. La Salle St., Chicago. The warehousing plant and Chicago district operation sales will continue at 1319 Wabansia Ave., Chicago.

The *American Nickeloid Co.,* Peru, Ill., is celebrating its fiftieth year of manufacturing preplated metals in sheets and coils.

In an effort to consolidate its manufacturing facilities into a more concentrated structure, *Jack & Heintz Precision Industries, Inc.,* Cleveland, has decided to sell its Berea Rd. plant. The company has also completed arrangements with the War Assets Administration for the purchase of machinery and equipment, now under lease, and has started negotiations with the WAA to purchase buildings Nos. 3 and 4, part of its Bedford plants, which are also now held under lease.

The head offices of the *Titanium Alloy*

*News of...*

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*Manufacturing Co.* at 111 Broadway, New York City, and its plant at Niagara Falls, N. Y., has been taken over by the *National Lead Co.* Beginning immediately, it will be operated as a division of National Lead.

The *Doehler-Jarvis Corp.*, New York City, has acquired the former *Gordon Manufacturing Plant*, located on the Dixie Highway in Toledo, Ohio. The new facilities, expected to be in operation by Jan. 1, will be equipped for plating large die castings produced in the present Toledo Doehler-Jarvis plant, which has also recently been enlarged and modernized.

The first plant of its type in the New England area has been established at Norwalk, Conn., by the *Lithgow Corp.*—applicators of protective linings based on Bakelite phenolic resins.

The exclusive manufacturing and sales rights for the Charlotte Colloid Mill were acquired by the *Greenwich Machine & Tool Co.* Offices have been established at 30 Church St., New York 7, under the name of *G.M.T. Colloid Mill Corp., Div. of Greenwich Machine & Tool Co.*

The *Mullins Manufacturing Corp.*, Salem, Ohio, is erecting a factory addition to its Warren plant, to be completed in May, 1949. Also under construction is a two-story office building at Salem, which will house the company's general and executive offices. Occupancy of this latter building is expected to take place in February.

Two new buildings at 2360 W. Jefferson Ave., Detroit, were formally opened by the *Michigan Abrasive Co.* on Oct. 29. These new plants will house the company's complete fabricating facilities and general offices. All the Michigan Abrasive making equipment and operations will continue in the old plant at 1111 Bellevue Ave., Detroit.

The *Fulton Supply Co.*, 342 Nelson St., S. W., Atlanta, Ga., has been appointed distributors for brass and bronze rods by the *Titan Metal Manufacturing Co.*, Bellefonte, Pa.

The one-hundredth anniversary of the *C. G. Hussey & Co.*, Pittsburgh, Pa., was celebrated on Oct. 28. Hussey & Co., Pittsburgh's only copper rolling mill, is a subsidiary of the *Copper Range Co.*, Boston, Mass.

A newly created Technical Service Div. has been established by the *Diamond Alkali Co.* at its Painesville, Ohio plant. The division will function as a separate unit, and will be headed by Walter C. Bates as manager and Dr. George F. Rugar, assistant manager.

The *Cleveland Tapping Machine Co.*, Hartville, Ohio, has reaffirmed the following companies as its West Coast sales rep-

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resentatives: *Burgan Machinery Co.,* Inglewood, Calif., to handle California, Arizona and Nevada; *Star Machinery Co.,* Seattle, Wash., continues in Washington and Oregon; *Noland Co.,* Chattanooga, Tenn., now handles Tennessee, Alabama and Georgia; and *Frederic & Bates,* Shreveport, La., has taken over Louisiana, Mississippi and Arkansas.

The main line of machinery manufacture of the *Standard Machinery Co.,* Providence, R. I., has been acquired by the *Fenn Manufacturing Co.,* Hartford and New Britain, Conn. The machinery will continue to be built under the Standard Machinery Co.'s name. The acquired lines will be moved to the Connecticut plants of Fenn Manufacturing about the first of the year.

The *Zapon-Keratol Div.* of the *Atlas Powder Co.,* Stamford, Conn., has decided to discontinue the manufacture and sales of coated fabrics. However, the manufacture and sale of industrial finishes and of Revolite Laundry Roll and Press Covers will continue.

A new corporation devoted exclusively to research, development and distribution of nonmetallic minerals has just been formed. Known as the *Frankenhoff Corp.,* with offices located in the Chrysler Bldg., New York City, it will specialize in high quality diatomaceous earth products. The president of this new company is C. A. Frankenhoff, and the vice president is A. G. Frankenhoff.

## Societies

George N. Sieger was elected president of the *American Welding Society* for the year 1948-1949. Mr. Sieger, a national authority on resistance welding, is president of the S-M-S Corp.

The *Society of the Plastics Industry, Inc.* voted to change the name of the Low-Pressure Industries Div. to that of the Reinforced Plastics Div. The plastics products covered will remain essentially the same, however.

Tom J. Smith, Jr. has retired as president of the *Pressed Metal Institute.* Pending action of the board of trustees, P.M.I. activities will be directed by Walter A. Gorrell, a vice president.

The Research Committee of the *American Electroplaters' Society* has recently established a second fellowship at Princeton University to intensify the study of the nature and effects of porosity in electrodeposits.

The *Gray Iron Founders' Society* elected a new rostrum of officers for the current

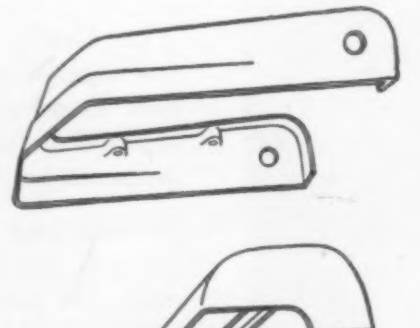
NEW PRODUCT IDEAS WITH CELLULOSIC PLASTICS

# ACETATE ADDS UP TO "SALES"

**FOR BUSINESS MACHINE MANUFACTURERS**


Suggested design for desk calculator by Carl Sundberg, Sundberg & Ferar, Detroit, Mich.

*Sectional view showing easily assembled two-piece housing. Keys and knobs are molded as separate units.*



**MOLDED IN CELLULOSE ACETATE FOR**

Dimensional Stability • Permanent Color & Finish
Thin-walled Toughness • Rapid, Secure Assembly
Lightweight

This design for a calculator housing is an excellent example of the many product advantages afforded by versatile cellulose acetate.

Shatterproof, resilient, lightweight, with a permanently lustrous finish, acetate is the ideal plastic for products that are subjected to day-in-day-out use. Dimensionally stable, it may be molded to close tolerances—permitting secure and rapid assembly with integral metal sections. New formulations even provide flame resistance.

Perhaps low-cost cellulose acetate housings or parts can add new durability and sales appeal to your product. Our technical service staff invites your inquiries.

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SUPPLIERS OF HIGH-QUALITY CELLULOSE DERIVATIVES FOR PLASTICS

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CELLULOSE ACETATE • ETHYL CELLULOSE • NITROCELLULOSE

*News of...*

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year at their recent annual meeting. They include Hermann P. Good as president, succeeding H. A. Stockwell. John E. McIntyre was elected vice president, Robert G. Schaefer, secretary; and Henry J. Trenkamp, treasurer.

Lawrence R. Martin, Donald F. Lyman and Dr. Jasper S. Chandler, all members of the Eastman Kodak Co., were the recipients of the Journal Award. This Award is given annually by the *Society of Motion Picture Engineers* for the outstanding paper on a technical phase of motion picture engineering published in the Society's journal during the preceding year.

The election of Joel D. Justin as chairman of both the Board and the Executive Committee of the *Engineering Foundation* took place at the annual meeting of the Board. Also elected were Dr. Boris A. Bakhmeteff as vice chairman, Dr. Edwin H. Colpitts as director, and John H. R. Arms as secretary.

The *American Institute of Mining & Metallurgical Engineers* has announced that William Wraith will be the recipient of the James Douglas Gold Medal for 1949. This award is made from time to time for distinguished achievement in nonferrous metallurgy. Mr. Wraith is consultant engineer to the Andes Copper Mining Co., Chile Exploration Co., Inspiration Consolidated Copper Co., and Greene Cananea Copper Co.

More than 100 people were present at the initial organization meeting and dinner given recently by the newly formed Utah Chapter of the *American Society for Metals*. W. C. Dyer, metallurgical superintendent at the Geneva Steel Co., was elected chairman of the new chapter. Don Rosenblatt, chief metallurgist of the American Foundry & Machine Co., was chosen vice chairman. Dr. H. Edward Flanders, professor of metallurgy at the University of Utah, was named secretary-treasurer.

The first recipient of the Gold Medal Award, donated by the *Gray Iron Founders' Society*, was Arthur E. Hageboeck, executive vice president of Frank Foundries, Inc. The medal was presented to Mr. Hageboeck for his outstanding contributions to the general welfare of the industry.

The *American Society for Metals* awarded the following individuals for their notable contributions to alloy steel development: Robert R. Abbott, Cleveland Heights, Ohio; O. H. Ammann, New York; Robert S. Archer, Climax-Molybdenum Co.; Wilbur H. Armacost, Combustion Engineering Co.; Edgar C. Bain, Carnegie-Illinois Steel Corp.; H. B. Batcheller, Allegheny-Ludlum Steel Co.; Quincy Bent, Bethlehem Steel Co.; A. L. Boegehold, General Mo-

*(Continued on page 168)*

# Index of Feature Material

# MATERIALS & METHODS

## Volume 28

### July—December 1948, Inclusive

Feature editorial matter from Volume 28 of MATERIALS & METHODS covering issues from July through December 1948 is indexed here. Material covered in the index includes feature articles, MATERIALS & METHODS Manuals, and Engineering File Facts.

For the sake of brevity, we have omitted from the index such departmental material as Book Reviews, New Materials and Equipment, Materials Outlook, Materials at Work, Editorials, Digests, and The Last Word.

# Authors' Index

# Index (Continued)

# The Last WORD

## A Hearty Season's Greetings

**from the Editors of MATERIALS & METHODS**

*(Top)*
W. P. "Bill" Winsor, Vice President and Publishing Director
*(Center, left)*
F. P. "Fred" Peters, Editor-in-Chief
*(Center, right)*
T. C. "Ted" Du Mond, Managing Editor
*(Bottom, left)*
Kenneth "Ken" Rose, Western Editor
*(Bottom, center)*
H. R. "Hank" Clauser, Associate Editor
*(Bottom, right)*
N. B. "Bruce" Bagger, Associate Editor

# TOUGH INSPECTION JOB?

## HERE'S THE ANSWER


## WESTINGHOUSE 250-KV JIB-CRANE X-RAY UNIT

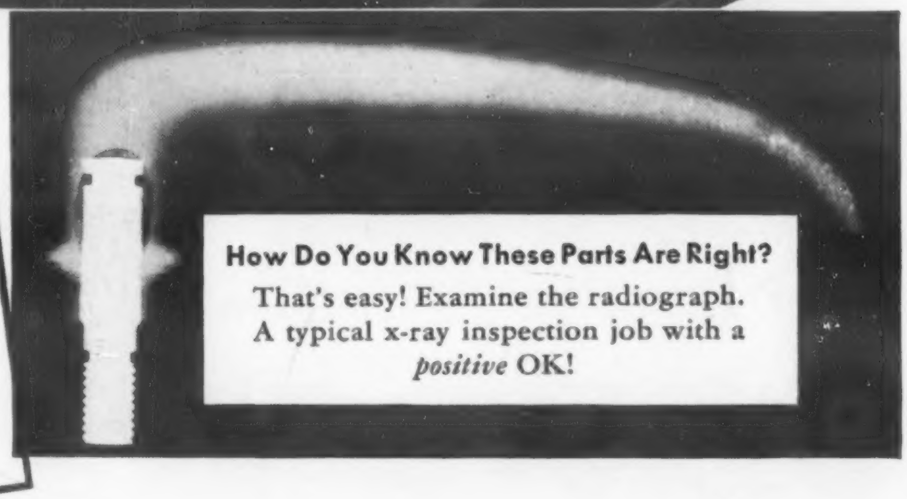
### Look at these features:

1 **SIMPLIFIED OPERATION.** Wall-mounted control incorporating X-Actron stabilizer holds current constant, regardless of line voltage variations. Operator has positive control of unit during all phases of operation. Boom is raised and lowered by electrically-operated hoist.

2 **HIGH PENETRATION.** Up to a maximum of 4½" of steel may be inspected, due to constant potential transformer design.

3 **VERSATILITY.** Vertical distance from tube target to floor is from 33" to 108" when unit is installed in 14" ceiling room. Tube travels 13' 6" along boom. Boom swings through nearly 180°. Tubehead rotates through 270° about its vertical axis and through 180° about its long axis, with positive locking in any position.

4 **SAFETY.** Every feature necessary for the protection of both operator and equipment has been incorporated in this unit. Meets all underwriter standards.



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That's easy! Examine the radiograph. A typical x-ray inspection job with a *positive* OK!

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X-RAY

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